# Appendix E
# Economic Analysis

**Draft Interim Feasibility Report**
**DeLong Mountain Terminal, Alaska**
**Navigation Improvements**

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## GLOSSARY

| | |
|---|---|
| backward linkage | A business that sells goods or services outside of the region and buys goods or services from other businesses in the region |
| ballast leg of voyage | That part of a ship's voyage during which she is not carrying any cargo and sailing in ballast |
| basic employment | Employment that is independent of the local market |
| bottleneck | Constraint, somewhere in the production system, that decreases the optimum efficiency of the system |
| draft | Distance from the keel to the water line of a loaded vessel |
| forward linkage | A business sells its goods or services to other businesses in the region |
| honey bucket | Containers used to catch human waste inside a house and carried to a disposal area |
| investment cost | The construction cost plus interest during construction. |
| non-basic employment | Employment that is serving the local market |
| open roadstead | A nautical term referring to an anchorage that has no restrictions on size or draft of vessel |
| opportunity cost | Where you have to give up something to get something else |
| sunk cost | A cost that has been incurred and cannot be reversed. |
| willingness-to-pay | The amount an individual is willing to pay to acquire some good or service. |

## ACRONYMS

| | |
|---|---|
| $/d | dollar per day |
| $/t | dollar per ton |
| AIDEA | Alaska Industrial Development and Export Authority |
| ANS | which is some kind of fuel |
| btu | British thermal unit |
| c/lb | cents per pound |
| CARB | which is some kind of gasoline |
| CSB | concentrate storage building |
| DOE/EIA | Department of Energy/Energy Information Administration |
| dwst | deadweight short ton |
| dwt | deadweight ton |
| EGM | Economics Guidance Memorandum |
| gpt | grams per ton |
| hp | horsepower |
| IFR | Interim Feasibility Report |
| IWR | Institute for Water Resources |
| kg/t | kilogram per ton |
| kmt | kilo-metric ton |
| kst | kilo-short ton |
| kt | kiloton |
| kWh/t | kilowatt-hour per ton |
| LME | London Metals Exchange |
| LOA | length overall |
| long ton | 2240 pounds |
| m | meter |
| mph | miles per hour |
| mt | metric ton |
| NAFTA | North America Free Trade Agreement |
| NANA | NANA Regional Corporation |
| NED | National Economic Development |
| NEPA | National Environmental Policy Act |
| NSB | North Slope Borough |
| NWAB | Northwest Arctic Borough |
| PW | present worth |
| st | short ton (2000 pounds) |
| swt | short wet ton |
| TCAK | Teck Cominco Alaska |
| tonne | metric ton |
| USGS | United States Geological Service |
| WTP | willingness to pay |

## SYNOPSIS

Out of the numerous alternative plans that were investigated, this appendix summarizes the economics of a handful that competed as potentially the best public investment. The best plan in NED terms proved to be a 53 ft channel with access to a trestle designed to accommodate an extended conveyor system. The conveyor will be capable of loading deep draft ships without the use of a tug and barge lightering system. Doing away with the tug and barge lightering system is a source for about 41% of the estimated transportation cost savings.

The proposed improvements will also reduce the cost of shipping fuel into 47 villages scattered over a geographic area nearly comparable in size to the state of California. This is accomplished by allowing for deep draft tanker fuel delivery to Portsite with short-link redelivery from there using fuel barges. This use of deep draft tankers reduces the delivery cost per unit of fuel by replacing long-haul tug and barge combinations.

The bulk purchase of fuel in deep draft tanker loads allows a lower purchase price, while the lower cost of operating tankers, instead of a tug and barge fleet, is a source of the rest of the fuel cost savings. Together the lower cost purchase and the lower cost transportation make up about 42% of the transportation cost savings.

Port improvements will provide other transportation savings to Red Dog Mine, the world's largest zinc producer. Reducing the prospects for congestion at the existing port and improving the throughput capacity allows for the balance of the savings, about 17%.

The NED plan is Alternative 11, a channel-trestle combination with a 53 ft access channel. It has benefits and costs as follows:

| | |
|---|---|
| Tug and Barge Cost | $10,788,300 |
| Port and Queue | $3,333,200 |
| Induced Tons | $1,707,900 |
| Fuel | $11,002,400 |
| Avoided Cost | $66,900 |
| Total Annual Benefits | $26,898,700 |
| Total Annual Costs | $22,339,300 |
| Annual Net Benefits | $4,559,400 |
| Benefit-to-cost ratio | 1.20 : 1 |

Project investment cost is $250,835.600. Total annualized cost is $22,339,300 and about 84% of the funds required for the project's annual cost are provided by non-federal sources.

# 1.0 INTRODUCTION

## 1.1 Purpose

The purpose of this section of the Economic Analysis Appendix is to prepare the reader by describing in general the type of analysis being presented and by highlighting some of the unusual or complicated aspects of the work. The Appendix is divided into sections that establish the economic inputs for selected aspects of the evolving benefit-cost study. These appendix sections and the order of their presentation is as follows:

**Introduction**. Provides an explanation of report organization and content.

**Regional Economic Base and Employment Impacts**. Identifies the study area and describes the social and economic characteristics. Describes the economic base and economic structure at the borough and census area level and draws a summary conclusion about potential employment impacts attributable to the recommended plan.

**Commodity Projection**. Establishes economics of the Red Dog Mine as a world competitor, evaluates supply and demand, and shipping needs, investigates variable output levels, inventories regional resources, and concludes with derivation of a most likely output level.

**Deep Draft Fleet Projection**. Looks at destination ports, historical shipments and vessel cost, and then estimates an optimum fleet mix given port constraints and market needs. Derives vessel operating cost using standard Corps' vessel operating cost tables.

**Tug and Barge Cost**. Reconstructs the cost of the dedicated fleet and estimates the NED economic benefit achieved by a reduction in the fleet.

**Induced Tonnage**. Simulator results show shipping throughput could be increased because of fewer shipping interruptions in the with-project condition. With mine target output held constant, increased reliability of the shipping system results in fewer tons being left behind at the end of the shipping season. The NED Benefit is explained as willingness to pay for the increment of tonnage net of production and shipping cost.

**Fuel Tanker/Fuel Barge Service (appearing as seven report sections)**. In the without-project condition fuel is delivered to northwest Alaska by barges. In the with-project condition a deep draft tanker will be able to deliver fuel to Portsite giving it status as a regional fuel redistribution portal for 47 communities scattered from Barrow to the Yukon delta. The cost of fuel delivery with the project, and without the project, are compared and NED benefits are derived. These sections also show the fuel cost difference between the west coast of the U.S. and Singapore by a display of historical data from documented industry sources. The comparison demonstrates a statistical and structural basis for asserting that fuel will continue to be cheaper by $.15 per gallon when purchased at Singapore instead of the west coast of the U.S.

**Benefit-Cost Evaluation (appearing as three report sections)**. One benefit category, Avoided Cost, is presented only in these sections. Results of the shipping simulator are applied to determine throughput and queuing with various project configurations; adjustments are made to convert all benefits to equivalent annual values. This section ties together all of the earlier benefit and cost analysis to show how the alternative plans compare. It also shows how the benefit and cost data are used to optimize NED depth, channel-trestle length, and turning basin depth.

**Sensitivity Analysis.** Twelve important variables are tested by changing their values to observe the impact on the "most likely case." Results are expressed in terms of differences in NED benefits and potential impacts on plan formulation.

Closely related to the above sections is one stand alone report that is contained in Appendix F of the interim feasibility report (IFR):

**Shipping Simulator**. Prepared by AMEC under contract with AIDEA, the report summarizes a Monte Carlo shipping simulator, which is used to verify throughput, delay, and queuing. It also describes the program logic and shows input files and relevant output summaries.

## 1.2 Methodology

The appendix contains a number of methodology applications necessary to identify and quantify the National Economic Development (NED) aspects of the study, and each is explained before being used. The intention is to maintain a consistency with Corps evaluation guidance as set forward in ER 1105-2-100 and related documents. Where Corps' guidance is not specific with regard to certain economic evaluation issues, or where various interpretations are possible, consultation with the Corps was initiated, Corps' reports were reviewed, and resource economics literature was consulted. Nevertheless the intention is to rely on Corps' guidance as the baseline, because there are certain agency policy interpretations that might vary from other sources. Notwithstanding this, Corps' guidance is applied as a broad framework for NED evaluation as derived from the Water Resources Council's, "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies", March 1983 (P&G).

A major contrast exists between economic evaluations of public investments, based on NED concepts, and ordinary private sector economic evaluations from the point of view of the firm. In general, the NED evaluations require inclusion of all identifiable effects while economics of the private sector emphasizes the capturing of issues relating to profit and loss of the firm. This contrast in frames of reference crops up repeatedly in the benefit-cost analysis, because some of the public benefits for this particular navigation project accrue to Teck Cominco Alaska (TCAK), presently the sole user of the port facility. Thus many of the economic effects are viewed one way by the company (profit and loss to the company), and another way by the Corps (positive and negative effects to the nation's public welfare as a whole). Complicating the matter is the use of private vs. public sets of accounts; the private sector uses financial accounting to measure net present value in its report annually to shareholders while public agencies use "opportunity cost," net benefits, and benefit-to-cost ratios to guide economic decisions of water and related land resource planning issues in the public arena.

Opportunity cost is the idea that relevant cost of a resource is determined by its value in the best alternative use. When markets are competitive, opportunity costs of resources equal their market prices. Unfortunately in the shipping industry the market relationship between buyer and seller is usually presented as a rate structure representing a bundle of services effectively masking the incremental cost aspects of specific services and making the real resource cost unclear. Complicating this convention in this study is the fact that for some of the shipping services there is a single buyer at Portsite (TCAK), and for some services a single seller (Foss Tug and Barge). There is also a single buyer and seller for fuel supplied at Portsite. In order to avoid the economic distortion of a reliance on rates in this situation, the NED analysis depends primarily on reconstructed costs, and this takes on a high level of importance in this study. In this study a good portion of the analysis of shipping cost is for the purpose of verifying reconstructed cost and demonstrating a comparison and reconciliation with estimated private financial costs.

The issue of financial cost vs. opportunity cost; private cost vs. public cost; rates vs. reconstructed costs all present major choices needing to be made in order to carry out the NED evaluation. Unless otherwise stated, the price level for alternative project costs is October 2004 and the interest rate used in analysis is 5 3/8%. Also, in this report the choice is to use the following conventions:

**Fuel Cost Differential**. The recommended plan will accommodate deep draft tankers, which will bring in fuel from Singapore where it can be purchased for $.15 gallon less than the west coast of the U.S., the origin in the without-project condition. Details regarding the differential purchase price can be found in the Section of the Economic Analysis Appendix titled Fuel Tanker/Fuel Barge Service.

**Vessel Operating Cost**. Standardized deep draft vessel operating costs are prepared by the Institute for Water Resources (IWR) for use on all Corps' navigation studies and are used herein as required by Corps' guidance. Tug and barge costs are also required to reflect standardized Corps' cost data. For the arctic tug and barge fleet applicable to this report, the Corps has no similar equipment in its standard database. Therefore equipment in use was inventoried and costs were reconstructed consistent with standardized Corps' procedures.

**Fuel Prices**. Market sampling of fuel cost at regional ports is used to establish a market value equivalent to opportunity cost of fuel for tug and barge operations. During the preparation of this report, the value is $1.40 per gallon and is a major contrast with the rate based agreement that, for example, supplied bulk fuel to Portsite at the cost of $1.01 during 2001. The $1.40[1] includes the cost of delivery, transfer, storage, and reselling in units of 600 gallons. The $1.01 includes only the rate derived financial cost of bulk delivery to Portsite for a unit of over 20 million gallons. Bulk delivery of fuel to villages immediately in the vicinity of Portsite, such as Kivalina, reported the local cost at $1.62, and the local fuel cost as reconstructed from utility data is $1.88. Noorvik reported fuel cost at $1.59, and the cost reconstructed from utility data is $1.85. Corps' cost estimating parameters in (EP 1110-1-8) concur in $1.40 gallon.

The opportunity cost value of $1.40 was used in the reconstructed tug and barge cost and in the reconstructed cost of all ocean tow equipment, coastal lighters, and inland lighters. It was

[1] Derived from 749 actual sales in Alaska ports 2000–2003 (time period minimizes distortions of world terrorism). Energy Information Administration price projections in 2004 indicate long-term normalization of petroleum prices due to supply, demand, and substitution effects with minimal variations from 2001 prices at about .2%–3% annually with national economic growth of about 3% per year. See Annual Energy Outlook 2004 with Projections to 2025, Report No.: DOE/EIA-0383(2004), Release date: January 2004. Accessed at http://www.eia.doe.gov/oiaf/aeo/.

applied uniformly in the without-project condition and in the with-project condition, and the effect of the fuel cost differential ($.15 per gallon saving) was accounted for separately. The effect on project benefits of using different fuel costs is revealed in the Sensitivity Analysis Section of the Appendix.

**Shipping Simulator**. A Monte Carlo simulator was developed for this study, and the benefit evaluation is closely related to it. The simulator is summarized in the Economic Analysis Appendix, Section 15, titled Benefit Categories, but the main discussion, including detailed input and output files, is in Appendix F of the IFR titled Simulation Model.

**Engineering Data**. For this study there is a generous amount of data regarding certain Portsite engineering information and relatively less economic information for the study area in general. This apparent inconsistency arises from the fact that Portsite has been undergoing engineering since before 1989, and the wealth of private sector information has not been culled to differentiate between data suitable at the feasibility report level of study and that suitable for future more advanced stages of study. Generally a good deal of the private sector engineering information has been developed to the level of precision appropriate for post authorization work. Wind, wave, and current inputs are derived from the Hydraulic Design, Appendix A of the IFR. In contrast the Corps of Engineers' planning and economics data is consistent with the feasibility report level of precision.

In contrast to this generously available data for engineering at Portsite, there is the publicly and privately available information needed for the economics. Public economic data of a detailed nature with consistency from one part of the study area to another is difficult to obtain partly because the study area is large, remote, sparsely populated, and in the early stages of economic development. Private economic data of a detailed nature is difficult to obtain because of disclosure problems. For example primary data about the Red Dog Mine, cost of operations, cost of fuel, contract shipping arrangements, etc., were not available because a single owner (TCAK) could suffer from disclosure of information important to be kept confidential for competitive reasons. Therefore a good deal of the information in the economic analysis is from secondary sources although the entire Economic Appendix was made available to TCAK in draft form for review and comment as it was being produced.

**Employment and Earning Data**. state data through year 2000 are based on the Standard Industrial Classification (SIC) coding system. Beginning with January 2001, the Standard Industrial Classification system (SIC) was replaced by the North American Industrial Classification System (NAICS). Changes in the employment classification system built distortions into time series that overlap the change. For that reason the bulk of the employment and income data in this report is locked into 2000.

**Population Data**. Verified population estimates were obtained from the state database. At the time population data was being incorporated into the report, state estimates for 2003 were the most recent data down to the village level. However for reasons of consistency with employment data, year 2000 population estimates were used.

**Assumptions**. Assumptions are clearly stated when they are first introduced. There are none that are so significant as to materially affect the outcome of the economics.

**Contingent Valuation Method (CVM).** A decision was made to not apply contingent valuation methods as a basis for benefit evaluation of non-market effects for the following reasons:

- To be valid CVM questionnaires require reference to use of a realistic payment vehicle, however, none exists in the project area.
- Commodity shipment is the same with the project and without it making potential project effects very fuzzy if not unidentifiable.
- Significant controversy exists regarding extrapolation of CVM findings to populations larger than the number of individuals actually interviewed.
- CVM studies typically home in on one major issue (such as the value of a marine sanctuary, or the value of subsistence harvests) while ignoring less obvious but possibly off-setting values (such as family stability, employment possibilities and career paths, community participation, gains to arctic engineering, environmental justice, self esteem, etc.).

**Potential Fuel Spills.** Not specifically estimated, this was treated as a constant between the with-project and without-project conditions. Reasons for not treating it as an increased risk in the with-project condition are:

- Total fuel use in the study area is essentially equal for both cases.
- Because a larger carrier will be used in the with-project condition, there are fewer fuel transfers, hence less risk of transfer spills.
- The with-project condition uses a double hull tanker.
- The with-project condition routing has less exposure of fuel barges to ocean conditions, because barge transport from Puget Sound and Kenai Peninsula are eliminated.

**Equivalent Annual Values.** The shipping throughput is fully developed to 1,544,000 swt of concentrate before project year one in 2011 when the benefit flow begins. However in this report the mine life is estimated at 40 years, effective in 2002, and the benefit flow occurs over the period 2011–2042 some 31 years of the 50-year project life. Equivalent annual values of costs and benefits are measured with 2011 being the base year.

Fuel delivery to regional villages will take place through the port in the with-project condition at a savings due to a more streamlined delivery system and point of purchase savings. This benefit stream will persist over the 50-year project life from 2011 to 2061 with the exception that 25,921,000 gallons delivered to the mine is assumed to cease around 2042.

The Federal discount rate current in this report is based on average market yields during the preceding fiscal year on interest-bearing marketable securities that have 15 years or more remaining to maturity. This rate is calculated by the U.S. Treasury and is required by the Water Resources Council's Rules and Regulations (33 F.R. 19170) section 704.39(a) and Section 80 of P.L. 93-251. The rate that was current during the time the bulk of the Economic Analysis Appendix was being finalized during calendar year 2004 and FY 2004 was 5 5/8%.[2]

[2] Corps policy statement and historical data accessed at, http://www.usace.army.mil/inet/functions/cw/cecwp/General_guidance/egm04-02.pdf.

The review draft was completed as the FY was progressing into FY 2005, and the author anticipated a rate change to 5 3/8% in FY 2005, and applied it to the economic analysis throughout this appendix to the IFR.

**Sensitivity Analysis**. Where a variation in methodology, assumptions, or data are suspected of having a notable affect on the outcome of the economic analysis, the methodology, assumption, or data is varied to reveal how sensitive the outcome is to changes in the independent variable. Selected independent variables are combined and tested in a single Section 17 of the Economics Appendix.

## 1.3 Plan Formulation

Plan screening includes economic analysis as well as other criteria. The alternatives, which made the long list in plan formulation, are presented in this Appendix. They include:

Without-Project Condition. This is a no-action baseline. It serves as the basis for comparisons of accomplishments of other alternatives. It is also a real alternative in the sense that no-action is a possible outcome of the planning process.

Alternative 2–3 Barges. This plan adds a third self-unloading barge to the two existing self-unloaders. For plan effectiveness and flexibility a fifth tug is also required. This is referred to as "Alt 2-3rd Barge."

Alternative 3–Breakwater. A breakwater is introduced to shelter the tug and barge operation. This is referred to as "Alt 3-BW."

Alternative 4–3 Barges and a Breakwater. These are introduced together seeking maximum output from the existing tug and barge mode. This is referred to as "Alt 4-3rd B & BW."

Alternative 5–Channel and Trestle Without Fuel. The channel-trestle combination would not include a fuel delivery element. This is referred to as "Alt 5-CH+TRS (w/o F)."

Alternative 6–Channel and Tunnel Without Fuel. In this plan a tunnel replaces the trestle. It does not include a fuel element. This is referred to as "Alt 6-CH+TUN (w/o F)."

Alternative 7–Offshore Fuel. This plan leaves the tug and barge operation in place and provides an offshore terminal for fuel transfer and adds to the tank farm. This is referred to as "Alt 7-OF."

Alternative 8–Offshore Fuel and 3 Barges. Fuel is provided by an offshore terminal, and the concentrate loading operation is modified with the use of a third barge with an additional tug. This is referred to as "Alt 8-OF+3B."

Alternative 9–Offshore Fuel and Breakwater. Fuel is provided by an offshore terminal, and the concentrate loading operation is modified with the construction of a breakwater. This is referred to as "Alt 9-OF+BW."

Alternative 10–Offshore Fuel, Three Barges and a Breakwater. Fuel is provided by an offshore terminal, and the concentrate loading operation is modified with the addition of a third barge and construction of a breakwater. This is referred to as "Alt 10-OF+3B+BW."

Alternative 11–Channel and Trestle with Fuel. This includes various depth channels in combination with varying length trestles. All of these channel-trestle combinations include facilities for fuel transfer and storage. This is referred to as "Alt 11-CH+TR (w/F)."

Alternative 12–Channel and Tunnel with Fuel. This replaces the trestle with a tunnel and is referred to as "Alt 12-CH+TUN (w/F)."

## 1.4 Tables and Figures

All tables and figures are titled and numbered. They are all inserted in the text to appear a close as possible to the place where they are first referenced. In all cases they are on the same or following page.

## 1.5 Sources and Notes

Sources that are directly related to information in the appendix are listed separately at the end of the document, and in most cases, the sources are also listed as footnotes where the source is first used. Footnotes and table notes are used also to explain numbers or statements that are put to use in one location but where the explanation of them is separated in the text.

# 2.0 REGIONAL ECONOMIC BASE STUDY AND EMPLOYMENT IMPACTS

**Purpose of the Regional Economic Base Study and Employment Impacts.** This economic base study describes selected aspects of the economic environment as a setting for the regional transportation problem being analyzed in this report and constructs a frame of reference or background against which socio-economic effects can be assessed. The direct economic and social effects of the alternative plans under consideration are identified in the context of this regional economic base study of a land area of some 214,300 square miles. Within this region the main economic impact of the recommended plan is centered a few miles south of the village of Kivalina, at the location of Portsite. The impacts from construction and operation fade proportionate to the distance from Portsite as the general impact area extends north and south several hundred miles and over 300 miles inland. The economic region for this study is defined primarily as the area where direct economic effects can be identified in terms of transportation savings made possible by the recommended plan.

Some parts of this feasibility report (the main theme) dwell on related aspects of at-site and regional economic effects, most of it in the context of NED evaluation. In contrast, the regional economic base study provides a setting for understanding the extent and nature of economic impacts at the regional level. From the regional economic base frame of reference, economic transfers are important; while from the NED frame of reference, economic transfers tend to cancel one another out.

There are several subsets of the overall regional economy presented elsewhere in this report as follows:

- The Commodity Projection Section compares production efficiency at Red Dog with all western world mines; it also looks at regional mining potential; and it looks at Red Dog's profitability with different product prices and production levels.
- The Induced Benefits Section explores the relation between effects of the alternative plans and increased mine profitability and output.
- The Fuel Tanker/Fuel Barge Service Section looks at changes in the regional fuel distribution system measured down to the level of specific villages.
- The Tug and Barge Cost Section addresses the tie between remote arctic operations and annual cost of operations.
- In an overall presentation of investment choices in the Benefit-Cost Evaluation Sections, associated costs are addressed and alternatives are compared against each other, including all costs and all benefits.

**Study Area.** The multiple beneficiary aspects of the project persist over a sparsely populated geographic area over 90% the size of the state of California. It is impossible to define the capture area with a great deal of precision because unlike other states, Alaska is not a matrix of highway systems, railroads, and commercial centers. Therefore the hinterland of transportation nodes and connections among economic subregions has fewer obviously recognizable characteristics, boundaries, and perimeter edges. In general the study area includes the coast and inland area from Kaktovik on the Arctic Ocean southwest to the

Yukon Delta. The study area does not correspond with either geographical or political boundaries and is bounded by the heavy dashed line, found on figure 1. The boundary is based on the geographical area where direct economic effects of the project are anticipated to be evident. The vertical distance of the study area is over 600 miles long.

Alaska political landscape is different from the county/state relationships found in the lower 48 states. Alaska does not use counties and depends on boundaries established by 16 boroughs and 11 census areas. The following table gives an overview of the political entities that impact the state; table 1 gives some data for the study area, shown in figure 1.

| State | Tribal | Alaska Native Claims Settlement Act | Level |
|---|---|---|---|
| State of Alaska | Alaska Inter-Tribal Council: Statewide Tribal Organization (177 tribes); advocacy for tribes. | Alaska Federation of Natives (AFN): Statewide Native Organization (non-tribal). | Statewide |
| Borough Assembly: State chartered regional municipal government. | Regional Tribal Consortium/Non Profit: Service delivery to tribal members/tribal advocacy. | ANCSA Regional Corporation: State chartered regional for profit; owns subsurface rights. | Regional |
| City Council: State chartered municipal government. | Tribal Council: Federally recognized tribal government by Bureau of Indian Affairs. | ANCSA Village Corporation: For profit village corporation; owns surface rights. | Local |

**Table 1. Study Area[3]**

| Political Area | Population | Square Miles |
|---|---|---|
| Northwest Arctic Borough | 6,897 | 36,000 |
| North Slope Borough | 7,367 | 90,000[4] |
| (only the populated Western half is impacted) | | |
| NCA | 9,200 | 23,000 |
| Wade Hampton Census Area | 7,000 | 17,000 |
| Yukon Koyukuk Census Area pop 6,500 (only the lower half with 1,793 people is impacted) | 1,793 | 48,300 |
| **Total** | **32,257** | **214,300[5]** |

In the text which follows, the individual political areas are discussed separately with an attempt at presenting data for each in a comparable format to the extent data is readily available. Despite the huge size of the study area and the numerous small communities, in the end there is a great deal of homogeneity among the areas with regard to them being quintessential rural Alaska, sparsely populated expanses of wilderness dotted by small villages that are primarily Native in culture and heritage.

[3] Statistics describing the study area and a large part of the text are edited from state of Alaska sponsored publications such as various articles in recent issues of Trends published by the Alaska Department of Labor, Research and Analysis Section and data from the U.S. Department of Commerce, Bureau of Economic Analysis, and Bureau of the Census, and other data sources such as the state of Alaska Community and Economic Development Database.

[4] About half of this land area is beyond the effective saving radius of the alternative plans.

[5] Reducing the political subdivisions in size to capture the land area inside of which economic effects are felt yields 145,150 $mi^2$.


Figure 1. Study Area Map

**Overview of Findings**. There is no known source of data specifically for the study area, and some of the data available for boroughs and census districts is not consistent in terms of format or most recent year of data available. Although a great deal of data is available for years as recent as 2003 and 2004, 2000 was selected as the representative data year for reasons of consistency. Adequate data is available to support the following conclusions relating to the study area:

- With a study area over 90% the size of the state of California but with 1/1000 of the population, community populations are typically small, communities are isolated, and the economies are not diverse.
- Per capita incomes within the study area are below the state norm.
- In the traditional sense a regional economy, founded on the export of goods and which in return receives an inflow of capital, is essentially absent.
- Government is a major employer in rural Alaska and, at the local level of rural Alaska, it generally constitutes a basic industry, because it represents local employment funded from outside.
- Nonresident employees and owners exacerbate a drain on the economy.
- A large share of goods and services are brought in from outside thus limiting the number of non-basic jobs available.
- Local job creation, resulting from the proposed navigation project is anticipated to be minimal, because trade patterns attract supporting goods and services from outside the study area, and thus, limiting re-spending within the study area.
- If savings in cost of fuel are passed along, it will expand disposable income at the household level throughout the study area.
- A review of historical data indicates that the only notable structural change of the study area economy in the last two–three decades is establishment of the Red Dog Mine which began operations in 1989 and provides a large block of basic jobs present today. There are no expectations for increased output, for change in the number of employees, or in the amount of wages paid.
- Although new minerals may be discovered and new mines may be opened, there is at the present time no demonstration of economic viability of potential major future industrial development at specific locations in the study area. A case for economic viability would be needed to tie the many available early-stage development scenarios into supportable spin-off growth projections. There is no indication that the recommended plan would be decisive in any such development scenario. The recommended plan will have an obvious presence and contribute to economic savings but will have no discernable impact on inducing or accelerating new industrial development.

**Economic Base Study Methodology**. It has become almost routine during the last decade to adapt the Leontief Input-Output (I-O) model approach to regional economic issues. One popular adaptation, allowing an easy to manage application of I-O, is the IMPLAN model, which was originally developed by the U.S.D.A. Forest Service in cooperation with the

Federal Emergency Management Agency (FEMA) and the University of Minnesota. It is available through Minnesota IMPLAN Group, Inc.

There are applications of this IMPLAN model readily available that allow it to be used with versatility on household PCs. The IMPLAN model is a step-down version of the larger national I-O model and, when it is loaded with localized data representing the economy of a region, it can be used to estimate aggregate statistics for various sectors of any large diverse regional economy. The national I-O tables, upon which the model is based, are adapted for the county or state area by using estimated regional purchase coefficients (RPC). The regional RPC for a particular industry show the share of the regional demand that is supplied by the regional producers.

Using a stepped down version of the U.S. economy to measure what one anticipates to happen at a local or regional level is appropriate when the local or regional economy is adequately diverse, productive, and robust to relate healthfully to the national coefficients. It is ordinarily a routine matter for most I-O applications at the county or multi-county level in the lower 48 to make adjustments within the limits of the I-O model and accommodate different employment distributions and levels of leakage from the regional economy. However the combinations of remote and rural characteristics of northwest Alaska create islands of small communities lacking in traditional basic industry and which are neither economically interconnected, robust, healthy, or diverse. Complicating the potential application of I-O techniques is that inter-industry linkages at the village, borough, or overall regional level are indicative that there is a strong flow of funds from the region for support services and goods. This indicates rural Alaska's in-region inter-industry relationships and economic multipliers are unusual and in many ways different from the national coefficients embodied in step-down I-O models.

Aside from the, rural, small village environment where most of the population dwell, each village is isolated in the sense that there is no road network; goods and people must be moved by airplane most of the year, when the rivers and ocean are frozen, making the economic and social interactions unlike any other part of the U.S. There is little in the way of national economic models that can be transferred to measure economic activity, impact, and potential at the level of isolated rural northwest Alaska villages.

A hard fact of the rural northwest Alaska economy is that the strongest employment sectors are typically government and education, and both of them survive only with the help of transfer payments. This gives them a characteristic of quasi-`basic industries in contrast to their characterization as typically non-basic or support industries when viewed at the state or national level. Another unique aspect is that characteristically the basic industries of rural Alaska do their spending outside the region by importing goods and services from the few metropolitan centers in the state or from the west coast of the U.S. Employee wages are also typically spent outside whether for the mining, petroleum, or fishing industry. Many employees are either seasonally supplied from outside with homes outside or are rotated between job sites and place of residence (usually out of the region) as frequently as every two weeks. There is little basic employment in the traditional sense of exporting manufactured goods, and most of the support goods and services needed by the basic industries are shipped in as needed; all of this making the sophistication of a I-O model ineffective and inviting the use of a regional base model.

For isolated areas such as regions of rural Alaska where villages of less than 1,000 persons are separated from others by many miles of wilderness, the traditional economic base model is usually more practical although it too is far from perfect. In its simple form it recognizes that some industries supply markets, which are outside of the region or otherwise attract dollars from outside, and that these industries are crucial to the local economy and are called the economic base of the region. Although not the only reason for economic growth, knowledge of the role of basic industries can explain a great deal about economic well being, the prospects for growth in a region, and the impact of new expenditures or other changes introduced from outside.

The economy of any major political unit is generally composed of smaller regional economies and these regional economies have economic relationships (linkages) among the parts. For example, the Red Dog Mine, which would be a basic industry because it sells output outside of the region, will buy transportation services from other firms in the region. This is called a backward linkage. There is no forward linkage of the mine in that none of its output is sold to other firms in the region.

The economic base model says that there is some employment in a region which is serving the local market and some employment which is independent of the local market. This latter employment is called basic employment. The other employment is called local market serving employment or, non-basic, or support employment. An example of this non-basic employment in a typical economic region (rural Alaska is untypical) would include grocery stores, restaurants, movie theatres, laundry mats, automobile service, entertainment, etc., generally those business that serve the local population. Also included at places other than rural Alaska would be government offices and schools supported by the region, however, in rural northwest Alaska these are generally considered to be part of the economic base because they are paid for by imported dollars (transfers).

Basic employment includes any employment in industries that have the kind of economic effect that export of products outside of the region would have such as the tourist trade which exports vacation experiences by importing spenders. In rural Alaska, employment in Federal Government agencies, for example, such as the Federal Aviation Agency (FAA), is also clearly basic employment. Even employment in state government agencies can serve as part of the economic base of an isolated rural region. Generally basic employment is any employment that is serving markets outside of the region and is independent of the local market, or that is providing services within the region but funded from outside the region (FAA, government supported health care, regional education facilities, state law enforcement, Federal environmental programs, etc). The economic base model is as follows:

Total Employment (TE) = Basic Employment (BE)+Non-Basic Employment (SE)

Support Employment (SE) is proportional to Total Employment (TE), SE:TE

Employment Multiplier = TE/BE

There are several methods for identifying the economic base industries of a region, including a method of location quotients where one divides the share of industry employment for a given industry within the region by the share for the same industry nation wide. The theory is that if the quotient is greater than one, then the industry is part of the economic base of the region, Although the concept of the location quotient is reasonable for a "normal region" and simple, it is not an error-free means for identifying the economic base for rural Alaska. Some of the problems with the theory are:

- Local conditions may cause the location quotient for an industry to be greater than one without it being part of the economic base such as the heating fuel business in cold climates.
- A region may have an industry that is relatively more important there than in nearby regions and consequently part of the economic base even though its location quotient is less than one such as education.
- The national economy may be a net exporter or net importer of the product of an industry, and this would affect the interpretation of the location quotient for this industry such as the U.S. being a net importer of zinc while Alaska is a net exporter.

Another means of identifying basic industries is with interviews and/or questionnaires seeking information regarding sales, expenditures, and income. This is expensive, time consuming, and must be done on a large scale to meet sampling and disclosure rules. One other method often used, where regions are small or where employment and industry patterns are unique, is an informed opinion from individuals trained to identify basic industries. Given knowledge of the observed economy, employment, and income data ordinarily recorded at the borough level, one uses common sense observations and professional training to judge which industries survive primarily on dollars they bring into the region (Basic Employment).

In this Economic Analysis Appendix, the regional base method is used with employment and income information at the borough level for specific industry employment. Multipliers are estimated from the relation judged to exist between total employment and basic employment. There is no extrapolation or projection of future change in the structure of the economy, and no economic projection is provided. This is because the study area is understood to be so huge and so sparsely populated that a growth projection in the usual and historic proportions of 1–2% does not add noteworthy numbers to the large area and does nothing to change the plan evaluation and selection in this feasibility report.

**Study Area Social and Economic Characteristics**. The residents of the study area are strongly tied to subsistence gathering and are somewhat dependent on goods brought in by boat and plane during the windows of fair weather. They are all unconnected by roads to the outside world. Many of the higher paying jobs are occupied by temporary residents, who cycle through on-off periods at mineral extraction facilities also owned by outsiders.

One theme that runs through the study area is that a principal employer is government, and this is also a consistent if not somewhat odd characteristic of rural Alaska. Typically it is local government that is the largest employment segment, and the largest single category of those jobs is education. Schools are not only the largest category of jobs, but the most important, because they exist in all inhabited communities by law.

Another theme running through the study area is the role of transfer payments, which tend to make up an inordinately large share of personal income. Transfer payments include fund transfers to non-profit agencies, retirement, public assistance, and other payments from government to individuals such as the state Permanent Fund, grants, retirement, disability benefits, etc. Typically, significant shares of the transfers are related to payments for health care; the Alaska Native population receiving free care by Federal mandate.

**Resources**. Alaska has been called a mineral storehouse for the United States, and it is evident that the economic structure of the overall region could change significantly if a profitable and environmentally friendly means of extracting and shipping some of the remotely located, known coal, copper, zinc, and other minerals were to be developed. There are huge resource reserves in the region, although the extremely high cost of building and maintaining transportation corridors presents a barrier to development at the moment. In the foreseeable future, mineral deposits will continue to be discovered, and at some point in time, the quality and quantity to be moved could conceivably become great enough to reduce the unit cost of transportation to a manageable amount. The likelihood of this happening and the timing of it cannot be specified beyond the level of "scenario analysis" with so many unknowns that possibilities for development in any timeframe can only be regarded as uncertain. One can conclude reliably, however, that the transportation efficiency gains provided by Portsite project are so minute in terms of the overall regional needs for future mineral extraction that they are not significant enough to sway the balance of the viability issue in a way that by itself would spur any future development.

Since the present day viability of mineral development, beyond the immediate vicinity of Red Dog Mine (Red Dog), has not yet been demonstrated, there is no need in this report for a detailed discussion of the resources or the many plans which have been investigated for marketing them. Instead it is recommended that curious readers refer to the maps, plans, discussions, and memos published in volumes of, Northwest Alaska Resource Development Transportation Alternatives Study, prepared for Alaska Industrial Development and Export Authority by $CH^2M$ Hill and Sandwell Inc. in December of 1992 and updated in 2001 as Resource Transportation Analysis (RTA).[6] The resource discussion in this economics appendix is limited to an overview directly related to the Delong Mountains area near Red Dog Mine and the following two paragraphs were edited from the RTA. For details regarding zinc extraction from the vicinity of the Red Dog Mine, the reader should refer to the Commodity Projection section of this Economics Appendix.

The Delong Mountains Mining District includes the Red Dog Mine and several other significant mineral prospects. The Red Dog Mine has overland access from the Delong Mountains Transportation System (DMTS) road, which links the mine site to an industrial port 55 miles away on the Chukchi Sea coast referred to as Portsite. The communities closest to Red Dog are Kivalina (about 55 miles southwest), Noatak (about 34 miles south), and Kotzebue, the regional center (about 82 miles south).

In Alaska mineral history, the Delong Mountains Mining District is a relatively new mining district. Its mineral resources are mainly base metal ores (zinc, lead) with some associated silver. The Red Dog Mine was developed by Cominco Ltd., now known as Teck Cominco Alaska and referred to as TCAK, on property owned by NANA (regional Native corporation in Northwest Arctic Borough) and is the only active mine in the district. The Red Dog Mine began operation in 1989, and first shipped ore concentrates in 1990. Red Dog zinc and lead

[6] Resource Transportation Analysis, Draft Phase 1 Report, April 2001, prepared for Alaska Department of Transportation and Public Utilities.

production climbed steadily during the 1990s. Today, Red Dog is the world's most productive zinc mine and Alaska's premier mine property. In 2000, the estimated value of Alaska's total non-fuel mineral product value was $1.13 billion,[7] and the value of Red Dog's output was $226.8 million or about 20 percent of the state total.

## 2.1 Northwest Arctic Borough

**Northwest Arctic Borough.** Hugging Kotzebue Sound and belted by the Arctic Circle, the Northwest Arctic Borough (NWAB) is Alaska's second largest borough. Only the North Slope Borough is larger. The NWAB covers approximately 36,000 square miles and is roughly the size of the state of Indiana. Its current population is roughly 6,897. Its landmass encompasses the drainages of five major rivers: Wulik, Noatak, Kobuk, Selawik, and Buckland.

Although the NWAB covers a vast geographical area, it is one of the most economically and culturally unified regions in the state. One of Alaska's most impressive economic powerhouses, the Red Dog Mine, operates in the remote area of the Borough. In fourteen years of operation, it has become the world's largest producer of zinc ore. Its flow of income to borough residents from the new private sector employment has spurred income growth and has greatly improved the NWAB overall wage and employment picture.

Although many residents benefit from the mine, others still rely heavily on subsistence resources. High unemployment, low labor force participation, and high incidences of poverty are still prevalent. Employment is concentrated in Kotzebue, and in most of the outlying villages, job opportunities are scarce. Because the NWAB has a very young population that soon will be entering the labor force, creating enough employment opportunities for these youth will be a challenge.

The vast majority of NWAB residents are Inupiat Eskimo, sharing a common language and similar customs. Subsistence remains a powerful unifying force. Most of the borough's communities can be found along four major rivers: the Noatak, the Kobuk, the Selawik and the Buckland. These four rivers converge on the coast near Kotzebue, which has developed into the region's largest community and hub through which nearly all goods to the borough's 10 other communities flow. A reflection of the area's tight economic and social integration is the fact that all of its key institutions including the borough; the Northwest Arctic Native Association (NANA); the area's regional Native corporation; the Northwest Inupiat Housing Authority; the NWAB School District; and Maniilaq, a health and social service provider, share virtually identical geographical boundaries.

**Regional Economic Environment.** Use of the term "mixed economy" has special implications in rural areas of Alaska. In the Alaska style mixed economy, households typically follow a pattern of activity that combines employment for cash with traditional fishing and hunting. Subsistence gathering makes contributions to the household food supply, but it also provides building material, fuel, raw material for tools and clothing, and arts and

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[7] Mineral Industry Of Alaska, Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys [DGGS], accessed at http://minerals.usgs.gov/minerals/pubs/state/980201.pdf.

crafts. Some villages are more traditional than others, but more than one still use the Native language daily and hunt with traditional methods such as the use of open boats.

Families engage in a seasonal round of subsistence activities, and it is common for them to move short distances as hunting, berry picking, or fishing draws them. In addition to use as food and raw materials, the wild resources are used in an informal network of distribution. The distribution system does not necessarily require that exchange takes place, because the fundamental purpose is to share the harvest. The situation in all of the villages is that sharing of the harvest ensures no one goes without. Generally, about half or more of the villagers will be actively involved in subsistence harvests in a major way, while all of the village will be involved in use of the harvest.

Cash income from employment opportunities (most often limited to seasonal income) is used to obtain modern technology to support the gathering of wild resources. Use of modern equipment such as snow machines, powerboats, nets, rifles, and traps enable individuals to continue to participate successfully in traditional activities across greater distances. In some Alaska villages, subsistence harvest still involves use of traditional methods pre-dating modern technology.

The presence of a mixed economy is more obvious in the smaller villages where the economic base is essentially absent. In contrast to the smaller more remote villages, Kotzebue, the regional center, presents a mixed economy with a stable and prominent economic base, and year around jobs that yield cash income. Unlike the smaller villages, a conventional life style in Kotzebue has much in common to small cities elsewhere. Woven into the fabric of the community is a working, productive population where over 70% of the population is Native people. In Kotzebue, more than the villages that depend on it, cash employment is more common. Its function as a service center to the region influences the type of wage employment found in Kotzebue.

Government services provide the major source of Kotzebue's employment. In year 2000, of the total workforce of 1,033, 438 worked for the Federal, state or local government. Of the 581 persons employed outside of government, the single largest class of employment was education with 163 jobs followed by retail trade accounting for 149 jobs, then transportation with 101 jobs. So it is clear from the employment profile that Kotzebue is serving as a regional center for government, trade, transportation, and education support.

**Borough Population**. The Northwest Arctic Borough is one of the most remote and sparsely populated areas of Alaska, and year-round access to the rest of the state exists only by air there being no road connections to the borough's 11 communities. During the warmer months when rivers are navigable, boats are the main transportation link among the villages. In the winter, the communities are linked by snow machine or dog team routes. The total resident population of the region in 2000 was 6,897. The region's communities range in size from near 3,000 in Kotzebue to about 100 in Kobuk. Kotzebue is the only community larger than 750.

**Table 2. NWAB Villages And Their Population[8]**

| Village | 1990 | 2000 |
|---|---|---|
| Ambler | 311 | 309 |
| Buckland | 318 | 406 |
| Deering | 157 | 136 |
| Kiana | 385 | 388 |
| Kivalina | 317 | 377 |
| Kobuk | 69 | 109 |
| Kotzebue | 2,751 | 3,082 |
| Noatak | 333 | 428 |
| Noorvik | 531 | 634 |
| Selawik | 596 | 772 |
| Shungnak | 223 | 256 |
| Total | 5,991 | 6,897 |

Even with a relatively high birth rate, population in the NWAB in the 1990s has grown by only 1.5% per year, a rate nearly identical to that of the rest of Alaska. But this is where the demographic similarities between the borough and the rest of the state end. While Native Alaskans comprise 16.7% of Alaska's population, more than 87 % of the NWAB's population is Native Alaskan, and nearly all are Inupiat Eskimos. There is no other borough in the state with a larger concentration of Native Alaskans. Only the unorganized area of Wade Hampton, which lies south of the Nome Census Area, has a larger concentration of indigenous people.

Northwest Alaska has one of the state's youngest populations, the region's median age in 1997 being 23.0 years, nearly 10 years less than the statewide median age of 32.2 years, and the household size is larger than average. At 3.75 persons per household, the borough's household size is surpassed only by the Wade Hampton region. The statewide average household size is 2.70. Another manifestation of the region's youth is the size of its school-aged population. Over 32% of its population is school-aged, versus 23% statewide.

**Red Dog Mine.** Located in the NWAB, the Red Dog Mine is a NANA (Northwest Arctic Native Association) joint venture with TCAK (Teck Cominco Alaska), the world's largest zinc concentrate producer. The ore deposits are owned by NANA and leased to TCAK, which owns and operates the mine, including most of its shipping infrastructure. As the single largest employer in the NWAB, the mine wields an influence on the region's economy not to be underestimated. The mine's workforce represents 16% of the borough's year 2000 wage and salary employment. Even more impressive are the wages generated by the mine. Red Dog payroll represents over a quarter of the borough's wage and salary payroll. In 1997, the mine's payroll was nearly $26.4 million, and its annual wages averaged $71,124, versus $32,520 for the rest of the borough. By 2001 the payroll had grown to $38.4 million and the average per employee was $73,700.

TCAK also provides the borough with the largest source of revenues through payments in lieu of taxes. When the mine opened in 1990, mining employment soared both in the NWAB and statewide. Red Dog represented the first large-scale mining operation to open in Alaska

[8] All of the communities listed except Noatak are incorporated.

in decades, and it remains the state's largest operating mine. Prior to Red Dog's opening, the average wage in the borough came in well below the statewide average; a year after the mine opened, the borough's average wage exceeded the state average. In 2000, the borough's average monthly wage was $3,282, compared to $2,893 statewide, and most of this premium can be attributed to the mine.

Most of the workforce at the mine works a two-weeks-on and one-week-off schedule. The expenditure of these wages and other spin-offs from the mine are the major reasons for the borough's relatively strong private sector. For example, a recent study found that more than a half dozen NANA subsidiaries are involved in providing services to the mine. Other contract partners and vendors profit from the mine's existence as well. Its influence on the borough's economy continues to grow. According to an article in Canadian Mining Journal, August 2002 by Jane Werniuk, Red Dog and its major contractors currently have 527 regular and 103 temporary (mainly summer) employees for a total of 630, of whom 62% are NANA shareholders.

**Kotzebue the Regional Center**. Kotzebue is a site that has been occupied by Inupiat Eskimos for at least 600 years. "Kikiktagruk" was the hub of ancient arctic trading routes long before European contact, due to its coastal location near a number of rivers. The German Lt. Otto Von Kotzebue "discovered" Kotzebue Sound in 1818 for Russia. The community was named after the Kotzebue Sound in 1899 when a post office was established. Since the turn of the century, expansion of economic activities and services in the area has enabled Kotzebue to continue to develop, and the city was formed in 1958. An Air Force Base and White Alice Communications System were later constructed.

A federally recognized tribe, identified as the Kotzebue IRA Council, is located in the community and 76.7% of the population are Alaska Native or part Native. The residents of Kotzebue are primarily Inupiat Eskimos, and subsistence activities are an integral part of the lifestyle. Each summer, the North Tent City fish camp is set up to dry and smoke the season's catch.

Kotzebue is the service and transportation center for all villages in the northwest region. It has a healthy cash economy, a growing private sector, and a stable public sector. Due to its location at the confluence of three river drainages, Kotzebue is the transfer point between ocean and inland shipping. It is also the air transport center for the region. Activities related to oil and minerals exploration and development have contributed to the economy. The majority of income is directly or indirectly related to government employment, such as the school district, Maniilaq Association, the City and Borough. Red Dog Mine is a significant regional employer.

Commercial fishing for chum salmon and processing at Kotzebue Sound Area Fisheries provides some seasonal employment. One hundred twenty-eight residents hold commercial fishing permits. Funding for the state-owned Sikusuliaq Springs Fish Hatchery was recently discontinued, and the City is exploring alternatives to maintain the facility. Most residents rely on subsistence to supplement income.

Air is the primary means of transportation year-round. The state-owned Ralph Wien Memorial Airport supports daily jet service to Anchorage and several air taxis to the region's villages. It has a 5,900 ft main paved runway and 3,900 ft crosswind gravel runway. A seaplane base is also operated by the state.

The shipping season lasts 100 days, from early July to early October, when the Sound is ice-free. Due to un-dredged river sediments deposited by the Noatak River, controlling depths at Kotzebue rule out deep draft shipping. Deep draft vessels (including most ocean going barges) must anchor 15 miles out, and cargo is lightered to shore and warehoused. Crowley Marine Services operates shallow draft barges to lighter cargo to area communities. There are 26 miles of local gravel roads, used by cars, trucks, and motorcycles during the summer. Snow machines are preferred in winter for local transportation.

As the nerve center for the outlying areas, Kotzebue is a transportation node that links the villages with the outside world. All goods must travel through Kotzebue by air or water. Major government functions are administered from Kotzebue. Social and medical services center on Kotzebue resources.

The importance of the regional center function is highlighted by harsh weather conditions, which close down water transportation for more than half the year and increase the risk of air transportation by small planes. The regional center functions as a year around nerve center, but activity is at a peak during the summer. Any interruption to the transportation system at Kotzebue creates the prospect of a delay in delivery to outlying villages and can result in downstream villages going without needed supplies for the duration of the winter.

None of the dependent villages are accessible by road even during the summer months. The villages are scattered over a large land area, and each of them has a gravel surfaced landing strip near the village. The communities have differing amounts of local infrastructure, but all of them share the use of Kotzebue based resources to make the community whole. Social and economic activity at Kotzebue does not stand alone from activities in the villages, because the flow of goods through Kotzebue are a lifeline to the villages.

Some of the dependent villages are situated along the coast, but all of them lack a suitable harbor to accommodate ocean going equipment that sails from Seattle–Tacoma, and Anchorage. Villages that depend on Kotzebue as a regional center must therefore arrange to lighter their supplies from Kotzebue. using smaller vessels or air charter flights usually from Kotzebue, Fairbanks, Nome, or Anchorage.

Delivery by air is expensive so is ordinarily reserved for high value low bulk items or for emergency needs. One exception has been the delivery of fuel oil on occasions when water delivery to communities on the Kobuk River has not been possible due to weather, low water levels, or equipment problems. Delivery by air is also used to provide emergency relief when local fuel supplies run low during the winter months. All of the villages are accessible by aircraft, although the length and condition of the landing strips limit the type and size of aircraft. For regional villages other than Kotzebue, low volume of passengers and goods makes it economically unfeasible to provide a scheduled air delivery service for anything but the U.S. Mail. The villages vary in size, but all, with the exception of Kotzebue, have a population of less than 1,000. Typically the population is primarily Native, and a subsistence life style is essential to survival, because there are few opportunities for career employment.

**NWAB Employment and Earnings by Industry.**[9] The most recent year for which comprehensive and verified published employment and earnings data for the borough was available, before the completion of the Economic Analysis Appendix, was for the 2003 calendar year. The 2003 data is of adequate detail to identify the basic and non-basic contributors to the regional economy; however, it uses a newly implemented North America Industry Classification System (NAICS). The NAICS replaced a classification system in use thru 2000 and employment numbers are generally not comparable from SIC to NAICS.[10] Since the Red Dog Mine developed prior to the change to NAICS, any time series analysis of the regional economy and its relation to development of the mine would be distorted unless tied to the SIC format. For that reason and because a cross-check comparison showed little change in the overall regional economy between 2000 and 2003, the SIC data, as presented in 2000, is used to explain the dynamics of the regional economy and the role of the mine.

The basic to non-basic relation is an important distinction, because it allows some inference to be made about the effectiveness and relationship between new investment and job creation; and new investment and contributions to the regional economy; and existing basic industry and the support jobs that it will encourage. The relation is not as clearly demonstrable in terms of earnings as in the tally of jobs.

The reasoning behind categorizing certain industries in the NWAB economy as basic industries is as follows:

Mining. Mining exports all production to smelters outside of the region so payroll dollars are brought in.

Heavy Construction. Construction is seasonal, and contractors sometimes mobilize equipment and labor from distant locations as needed; however, this is assumed to be work for outside interests (mine, road, and port development) performed by NWAB residents.

Transportation. Truck haul and air service provided by NWAB firms and which are paid for primarily by external sources including government, industry, and tourists.

Hotels. Presumed to provide service to the tourist trade and hence a regional export.

Health Services. A regional service center supported by transfer payments from state and Federal sources.

Government. Supported largely by transfer payments with 88% of expenditures sourced from outside.

The government sector deserves a special explanation. Huge defense assets, ownership of over 64% of the state's acreage, a special relationship with Alaska's indigenous people, protection of the state's extensive coastline, and a big Federal role in Alaska's extensive air transportation system ensure a strong flow of Federal funds into the state. The fact that the state was still a U.S. territory less than 50 years ago also helps explain the Federal Government's lasting economic influence.

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[9] The primary data source for employment by industry is Alaska Department of Labor accessed at http://www.labor.state.ak.us/research/ee/00ee97ex.xls.

[10] Alaska Economic Trends, July 2002 accessed at http://almis.labor.state.ak.us/article.asp?ARTICLEID=859&printerFriendly=true.

Economic researchers at the University of Alaska attribute most of the growth in Alaska's personal income in the 1990s to increases in Federal expenditures and Permanent Fund disbursements (a monetary dividend from oil revenues, given to every Alaska State citizen, every year]. Growth did not come from the "traditional" Federal expenditures such as the military or the civilian Federal workforce. Neither of these has grown over the past decade. Instead, retirement disbursements, other direct payments, procurement, and grants fueled the increase. These include social security and Federal retirements, Medicare, unemployment, housing assistance, and food stamps traditionally referred to as transfer payments.[11]

Federal grants to the state nearly doubled from $1.2 billion in 1995 to $2.2 billion in 2000. Such grants go mostly to state and local governments, universities, non-profit organizations, and sometimes individuals. Alaska received more than 400 separate grants in 2000. Major grant categories include $362 million for highways,$312 million for Indian Health Services and $282 million for Medicaid. On a per capita basis, Alaska ranks number one among the states in Federal grants. One result of this run-up in Federal grant monies is a very clear but not often discussed effect on the state budget. In 1990 state government received $548 million in Federal grants. In fiscal 2000 grants had climbed to over $1.5 billion.

In general, rural areas tend to have higher per capita Federal expenditures. Most of the expenditures flow into these areas via grants to local health care and social services organizations, housing authorities, and other organizations plus transfer payments, such as retirement, welfare, housing assistance, and medical payments are also important sources of Federal monies.

A detailed breakdown of employment by month among some 53 standard industrial classifications can be found at the Alaska Department of Labor and Workforce Development website.[12] The data is summarized here and sorted into two categories, one for basic industry employment and one for non-basic. Generally the basic and non-basic employment breakdown for the borough would be estimated somewhat as follows:

**Table 3. Basic/Non-basic Employment Relation**

| Industry | 2000 Employment |
|---|---|
| Mining | 515 |
| Heavy Construction & Special Trades | 33 |
| Transportation | 247 |
| Hotels | 56 |
| Health Services | 446 |
| Government | 980 |
| Basic | 2,277 |
| Non-Basic | 608 |
| Basic+Non-Basic (608) = Total | 2,885 |
| Ratio (Multiplier) = Total/Basic | 1.27 |

[11] Source: U.S. Census Bureau, Consolidated Federal Funds Report FY 2000.

[12] Alaska Department of Labor and Workforce Development accessed at http://www.labor.state.ak.us/research/ee/00ee97ex.xls.

With a total employment of 2,885 and an apparent number of jobs in the basic sector estimated at 2,277, there would be 608 non-basic jobs. Indications are that the economic make up of the borough is such that one basic job supports .27 of a non-basic sector job; or an indicated basic to non-basic employment ratio (multiplier) of 1.27 (creation of a new basic job will spin off .27 non-basic job).

In order to extend this relation to estimate the magnitude of secondary employment and income impacts from new basic jobs at the borough level, one needs localized income data representative of the basic and non-basic sectors. For example, if one accepts an average earning per job of $39,400 and the .27 basic to non-basic ratio, it follows that it takes $145,900 of new basic earnings to create one non-basic job. This is an inference based on the use of an average of income across all jobs, but will vary, if the average wage for basic industry employment is different from non-basic income, which is the case.

Statewide, the annual monthly wages in the metals mining industry are $5,533, and for all industries combined is $2,893, and for retail trade is $1,645. Selecting retail trade as representative of the non-basic sector, we would show that $5,533 of new basic sector wage income would create only .27 of a job; and four new basic jobs could create one non-basic job but it would be earning only $1,645, which is about a third of the wage in the basic industry. It would take about 12 basic jobs to create 3 added non-basic jobs, all of which would earn only as much as one basic job. This is an illustration of why healthy regional economic growth depends so much on establishing export based industry and why jobs at Red Dog are so important to the economic health of the region. It is also a good illustration of why one needs to know more than the employment effect from new investment to capture the telling arguments that describe how a regional economy withers or grows as a result of changes in basic economic activity.

**Subsistence**. While land in the NWAB offers great potential in mining, and other wage and income opportunities, subsistence activity represents an important source of non-cash income as well as employment. To some extent, subsistence resources help offset the much higher cost of living and the unemployment in the borough. Caribou, sheefish, salmon, seals and moose are the most important subsistence resources, but small game and berries are also harvested. The Western Arctic caribou herd, which is one of the largest in North America with nearly half a million animals, migrates through the region. Nearly the entire population engages in subsistence activities. In Kivalina, a community of 349, all households are involved with subsistence activities. The average household harvests 3,636 pounds of usable subsistence resources, or 761 pounds per person, according to a 1992 Alaska Department of Fish and Game study on subsistence resource harvest and use. Although subsistence may be relatively more critical to the smaller communities of the borough, where few payroll employment opportunities exist, most Kotzebue residents (74%) engage in subsistence harvests as well.

Reindeer herding for many years was an important source of both cash and subsistence. In recent years, many of the animals have been lost to the migrating caribou herds. Several herds were once owned privately, but now only one herder still has reindeer in his corral. Reindeer meat can be bought in local grocery markets in towns such as Nome, Kotzebue, and Barrow. Reindeer antler harvests, however, are exported from the region. In recent years, the price for antlers in Asian and domestic markets has been severely depressed.

Salmon provides a subsistence resource to the region, and there is also a small commercial fishery in the Kotzebue area. Most of the salmon harvested are chums, and recently, low catches and low prices have plagued this commercial fishery. In 20 years of fish harvest history, the 1998 catch was the smallest both in volume and in value. Only 22% of local fishers participated in the commercial chum harvest.

**Unemployment and Income**. Although job opportunities and wages have improved in the NWAB over the past decade, high unemployment, low incomes, and high rates of poverty persist in most of its communities. Economic and social indicators illustrate this phenomenon. For example, in 1996 the borough's per capita income of $18,392 ranked 20th out of 27 areas in Alaska. This compared with a statewide per capita income of $24,597. By 2001 the borough's relative status had not changed, having a per capita income of $22,901, compared with a state average of $31,027.

Part of the difference between the borough and the state can be explained by demographics. Because such a large share of the borough population is under 18, its income is shared among a proportionately greater number of people too young to work. However, the more telling explanation for this disparity is that fewer opportunities exist locally for employment, especially on a year-round basis. Unemployment in the NWAB typically runs at least twice the statewide rate, and in recent years was the highest in the state. In 2003 the unemployment rate for the state was 8% while within the borough it was over 20%. An even more telling statistic is the percent of the population that participates in the labor force. Statewide in 2002, 74% of the over-16 population was active in the labor market, compared to about 54% in the NWAB.[13] This is indicative of the high proportion of "discouraged" workers, those not actively seeking employment and not counted in the unemployment statistics. Not surprisingly, incomes and job opportunities are better in Kotzebue than elsewhere in the borough. Incomes are low and job opportunities scarce in the 10 communities outside of Kotzebue.

In some borough communities, a third of the population lives in poverty (based on cash income). The lack of employment and business opportunities helps explain most of these differences. Low educational attainment also plays a role. Per capita income in some of these communities is half the level found in Kotzebue or in the borough as a whole. High living costs exacerbate the impact of these lower incomes in the villages. According to studies conducted a number of years ago, costs run approximately 40–45% higher than they do in Anchorage. Taking into account the value of the subsistence harvest would reduce this differential. Given the demographics of the borough, there will be increasing pressure in the region to provide more economic opportunities as a growing number of residents reach working age.

## 2.2 North Slope Borough

**North Slope Borough**. The North Slope Borough (NSB) encompasses nearly 90,000 square miles of Arctic territory at the top of Alaska. It is the northern most land in the continental

[13] U.S. Census Bureau data accessed at http://www.census.gov/acs/www/Products/Profiles/Single/2002/ACS/Tabular/040/04000US023.htm.

U.S. and includes an area about as large as the state of Minnesota. On an annual basis, its coastal area has the coldest climate in Alaska; the region contains the nation's largest oil field; and Barrow, the northernmost community in the United States, has one of the largest Eskimo populations in the world. The borough has the world's largest local government in terms of area.

There are no roads in the NSB outside of the immediate village areas. None are connected to the continental road system except the haul road, which goes from Fairbanks all the way up to Prudhoe Bay, so travel is dependent on air today. There is some travel by snow machine in winter, when one can get just about anywhere to the extent that weather extremes allow.

**Population**. In 2000, the NSB population was estimated at 7,367. Typical of the smaller villages is short-term fluctuation around a core population that tends to remain fairly static over a long period of time. In terms of percentage gain, the following table shows a large growth in population during the 1990–2000, but this represents only a difference of 1,575 people. Although this could make up the entire population of more than one village, it is insignificant in the sense that the population of the NSB and the study area as well fluctuates seasonally by even larger numbers.

Taking away from the significance of population growth is also the matter that as some villages of the study area grow in population, others do not. Another consideration is the fact that the observed population growth is not a result of people being attracted into the area as a result of economic prosperity given that there is a 14.9% unemployment rate among those over age 16 actively searching for work. The rate is much higher if the large number of discouraged workers are included. Given these facts, population growth in the region could be adding to future transfer payments or eroding per capita personal income in the region. In either case the need for development of basic employment opportunities is obvious.

**Table 4. NSB Villages And Their Population**

| Village | 1990 | 2000 |
|---|---|---|
| *Point Hope* | 639 | 757 |
| *Point Lay* | 139 | 247 |
| *Wainwright* | 492 | 546 |
| *Barrow* | 3,469 | 4,581 |
| *Kaktovik* | 224 | 293 |
| Atqasuk | 216 | 228 |
| Nuiqsut | 354 | 433 |
| Anaktuvuk Pass | 259 | 282 |
| Total | 5,792 | 7,367 |

NOTE: Only the first five communities (in italics) are within the study area.

The nearly 90,000 mi$^2$ region includes 7,367 residents, which makes this part of Alaska about the most sparsely populated area in the U.S. About 70% of the population are Inupiat or 'the people' and were traditionally nomadic as hunters and gatherers. North Slope Borough used to have a strictly subsistence economy with a culture dependent on the harvest of the bowhead whale. Today, it is still culturally dependent on bowhead whaling. Subsistence is still important, but since development of the Prudhoe Bay oil fields in the 1970s, there is also a cash economy.

**Economic Characteristics of the NSB.** Government is the largest source of income in an economy that is oil revenue tax based or fee based, and all together, the combined governments employ about 1,000 people. Beyond administration of a tax structure, the North Slope Borough has nothing to do with the oil industry; however, the local Native Corporation, Arctic Slope Regional Corporation, (ASRC) does. The ASRC is a land owner and charges the oil companies not based on oil production but based on use of land that the oil companies occupy for their facilities. Therefore regardless of how the price of oil fluctuates or the amount produced, the regional corporation is provided a steady income source. The ASRC with over $1 billion of revenues annually operates a number of business serving the construction and resource industries. In contrast, the only source of income the NSB has is property taxes, although these taxes provide almost 60% of the operating budget.

The vast majority of the North Slope's people are Inupiat Eskimos. They reside in eight villages with populations ranging from 247 to 4,581. There are a number of outlying resource exploration and extraction sites having work crews, which are not counted in the village population and are not considered to be residents. Nevertheless these sites add a large number of people and include about 5,000 jobs not counted in the total of all of the village industries.

There are few employment opportunities in the villages outside of government jobs, and basic manufacturing is practically absent. Against this bleak background is the fact that the 5,000 persons who work in the regional oil fields actually rotate in and out on programmed work schedules. Neither they nor their income is counted within the borough.[14]

Comparing the economic fabric of the smaller NSB villages to the larger ones, a breakdown of employment is shown by village. The notable observation is that in the smaller villages, which are ordinarily among the more remote, there are fewer jobs, and those that dominate the economy are primarily in government, and healthcare and social services. Throughout the entire study area this contrast is typical, between few opportunities in the smaller villages coupled with a dependence on transfer payments and the more diverse economic viability of the larger regional centers.

**Barrow as a Regional Center**. The city of Barrow is the economic, transportation, and administration center for the NSB. Barrow, the northernmost community in North America, is located on the Chukchi Sea Coast, 10 miles southwest of Point Barrow from which it takes its name and is about 725 air miles from Anchorage. Today Barrow is the largest city in the NSB with a population of 4,581 of which 60% are Inupiat Eskimo. The area encompasses 19 $mi^2$ of land and two $mi^2$ of water. The climate of Barrow is arctic; precipitation is light, averaging 5 inches, with annual snowfall of 20 inches. Temperatures range from -56 to 78, averaging 40 during the summer. The sun does not set for 84 days between May 10th and August 2nd each summer and does not rise for 67 days between November 18th and January 24th each winter. The daily minimum temperature is below freezing 324 days of the year. Prevailing winds are easterly and average 12 mph.

During the 1940s and the 1950s the military played an important role in the area. During World War II, the Navy Seabees established military camps northeast of Barrow to explore

[14] Data from the Community Data Base, North Slope Borough, http://www.dced.state.ak.us/cbd/commdb/CF_BLOCK.cfm.

for petroleum reserves. Later, construction included the Distant Early Warning Line and the Naval Arctic Research Laboratory, 3 miles north of Barrow. Exploration of the Naval Petroleum Reserve Number 4 (now National Petroleum Reserve in Alaska, NPR-A) brought new development, people, and resources to the Barrow area. Formation of the North Slope Borough in 1972, the Arctic Slope Regional Corporation, and construction of the Prudhoe Bay oil fields, and Trans-Alaska Pipeline have each contributed to the continuing development of Barrow. Today fee revenues from the North Slope oil fields fund borough-wide services.

Most homes in Barrow have modern amenities with natural gas heating and modern water and sewer systems. Utilities are provided by Barrow Utilities and Electric Cooperative, a local member owned and operated cooperative, which provides electric power, natural gas, and water and sewer services. Water is supplied from Isatkoak Lagoon and is stored in a tank after being treated. Most residents have piped water sewer connections. However, some residents still rely on trucked water and honey buckets for sewage disposal.

Additionally, a large capital improvements project will provide all outlying villages with state of the art water and sewer systems. The North Slope Borough provides all other utilities and refuse collection services.

There are three schools located in the community with an enrollment of 1,105 students. In order to preserve the Inupiat culture, a standard curriculum is blended with the language, history, and traditional activities of the Inupiat people. Additionally, there is a post secondary education center, Ilisagvik College, located at the former NARL site. College courses are available to students in other locations through video teleconferencing.

As the seat of the North Slope Borough, many regional and health services are located in Barrow. The residents' health needs are met by the local hospital, Samuel Simmonds Memorial Hospital. Auxiliary health care is provided by the Borough Fire Department and the Borough Search & Rescue Department, which includes emergency medivac services to larger hospitals when required.

The state-owned Wiley Post-Will Rogers Memorial Airport serves as the regional transportation center for the area. Daily air service to Barrow from Anchorage is available and provides Barrow's only year-round access. Small planes fly from Barrow to the outlying villages on a regular schedule, weather permitting.

Barrow is the economic hub of the area. Approximately, one-third of the working population of 1,986 people is employed in the private sector, including the local regional corporation, ASRC. The local government employs 48% of the work force, and the school district employs another 13.5%. In the last census, the median household income was $56,688, and 7.5% of residents were living below the poverty level. Although Barrow is a modern city, subsistence hunting is still important to the local residents. Many residents rely upon subsistence food sources: whale, seal, polar bear, walrus, duck, caribou, grayling, and whitefish to supplement their diet and income. The midnight sun, the unique geography and climate, and the traditional lifestyle have attracted a growing tourism industry. The sale of local arts and crafts provides some cash income.

As one moves into the borough's seven outlying villages, modern amenities become less abundant and employment opportunities become more scarce. Some of the communities lack modern conveniences such as local water systems and indoor plumbing.

**Employment and Income.** The most recent year for which historically consistent, comprehensive, and verified published employment data for the borough, available at the time of this research, is for the 2000 census year. The data is presented in adequate detail to guide a sorting of employment into those jobs which are judged to be primarily basic contributors and those which are interpreted to be non-basic contributors to the regional economy. This basic-to-support relation is an important distinction because it allows some inference to be made about prospects for job creation, which can effectively enhance the health of the regional economy.

The basic or export based jobs are those which either export goods and services from the region or are supported by dollars that otherwise come into the region from outside. An example would be ASRC income from land ownership, because the payers are companies in the oil industry neither locally owned nor financed. Another example in this remote area would be the health care industry, which attracts patients from throughout the region and is funded through transfers and grants from state and Federal external sources thus bringing in both patient dollars and transfer dollars. Generally the breakdown for the borough would be somewhat as follows:

**Table 5. NSB Basic/Non-basic Employment Relation**

| Industry | 2000 Employment |
|---|---|
| Mining | 63 |
| Heavy Construction | 237 |
| Transportation | 278 |
| Hotels | 97 |
| Health Services | 1016 |
| Government | 688 |
| Basic | 2,379 |
| Non-Basic | 603 |
| Total | 2,982 |
| Multiplier = Total/Basic = | 1.25 |

Note: No industry is entirely basic or non-basic and sorting entire industries based on an observed prevailing characteristic leads to a probable over classification in the basic category. The amount of the over classification is unknown.

The basic-to-support relation is unbalanced. This is not unusual for remote village locations which rely a great deal on consumer goods being supplied by air or water from the outside. With a total employment of 2,982 and an apparent number of jobs in the basic sector estimated at 2,379, there would be 603 non-basic jobs. Indications are that each basic job supports only .25 of a non-basic sector job or an indicated basic to non-basic employment multiplier of 1.25 (creation of a new basic job will support .25 non-basic job).

In order to extend this relation to estimate the magnitude of secondary employment and income impacts of new basic employment at the borough level, one needs localized income data representative of the basic and non-basic sectors at the borough level. For NSB, the average earning per job is shown as $5,362 monthly. Given the estimated NSB .25 basic to non-basic ratio, it follows that it takes $258,000 of new basic earnings annually to support one new support job. This is a startling inference based on the use of an average of income across all jobs and will vary if the average wage for basic industry employment is different from non-basic income, which is ordinarily the case.

Details about earnings by sector are available from data published by Alaska Department of Labor and Workforce Development at the borough level for all industries. Borough wide, the 2000 annual monthly wage in the mining industry (selected as an indication of higher earnings in the basic sector), is $7,040 and for retail trade (selected as an indication of lower earnings in the non-basic sector) is $2,836. Using retail trade as representative of the non-basic sector, we would show that $7,040 monthly of new basic sector wage income would create .25 of a non-basic job; but that fractional non-basic job would be earning only $709 monthly, about 10% of the monthly wage for full time employment in the basic sector.

While there can be said to be a shortage of jobs among the borough residents, the NSB region is proportionately rich in export based employment but poor in the number of local non-basic jobs. This unfortunately indicates that a good deal of local earnings leak out of the local economy, because consumers must order goods and services to be brought in from outside the region. This is a good illustration of why healthy regional economic growth depends so much on establishing export based industry, and why basic industry employment must be balanced with a local non-basic sector as a recipient of consumer spending.

Establishment of non-basic industries, however, is economically impossible when communities are remote and their size does not supply the critical mass of spending necessary to provide adequate income to generate profits for new entry. The economic growth dilemma that this presents is obvious in the sense it indicates that the only reasonable prospect for expansion of income and employment is in the export based industries, because they bring dollars into the region while the supporting services sector does not.

## 2.3 Wade Hampton Census Area

**The Wade Hampton Census Area (WHCA)**. WHCA encompasses an area of 17,124 $mi^2$, an area about twice the size of Massachusetts. The WHCA is generally described as the delta and lower river areas of the Yukon River, and Kuskokwim River drainages. It consists of 21 small villages[15] with nine villages inside of the study area. Among them, St. Marys would most likely be considered a commercial hub, although it has a population of only 500. The nearest supply center is Bethel, located on the Kuskokwim River but not actually inside of the WHCA boundary, and outside of the study area. The longest road in the 17,124 $mi^2$ area is 22 miles long, connecting the village of Mountain Village with Pitka's Point. Typical of rural Alaska, travel and supply is dependent on boats during the ice free season and airplanes whenever weather permits.

**Population**. Nearly two thirds of the population lives along the treeless, wetland delta of the Yukon River or tributary streams; the balance occupies the three coastal villages of Hooper Bay, Chevak, and Scammon Bay. Hooper Bay is the largest community in the census area

[15] Village count found in Wade Hampton Census Area: Economic Overview accessed at http://www.commerce.state.ak.us/dca/AEIS/WadeHampton/General/WadeHampton_General_Narrative.htm.

and the only one with over 1,000 people. The entire WHCA has only 7,030 people and has a population density of .4 persons per square mile, compared to the overall Alaska density of 1.1 person per square mile. The populations of the established year-around villages in 1990 and 2000 are in the following table:

**Table 6. WHCA Population**

| Village | 1990 | 2000 |
|---|---|---|
| *Alakanuk* | 544 | 652 |
| Chevak | 598 | 765 |
| *Emmonak* | 642 | 767 |
| Hooper Bay | 845 | 1,014 |
| *Kotlik* | 461 | 591 |
| *Marshall* | 273 | 349 |
| *Mountain Village* | 674 | 755 |
| Nunam Iqua (Sheldon Pt) | 109 | 201 |
| *Pilot Station* | 463 | 550 |
| *Pitkas Point* | 135 | 125 |
| *Russian Mission*** | 246 | 296 |
| *St. Marys* | 441 | 500 |
| Scammon Bay | 343 | 465 |
| Total | 5,774 | 7,030 |

NOTE: Only villages in italics are within the study area. Seasonal camps are excluded.

The WHCA residents form the most homogeneous racial group within the boundaries of an Alaska Census Area or borough. Nearly 95% are Native Americans, mainly Eskimos. The majority of the remaining population is white, many of whom stay in the area only for a limited time due to professional reasons.

One unusual demographic characteristic is the young median age of the population, half of the residents being under 19 years of age. The working age population (18–64) makes up only 46% of the total compared to 64% state wide, helping to explain the low average family income. The WHCA is the poorest census area in the state. In 2000 WHCA personal per capita income was $8,717, some 38% of the state average of $22,660. The area is entirely rural; there is no commercial or administrative center to inflate the statistics of the small village economies.

**Employment and Income**. Year 2000 personal income data for the WHCA shows that of the total personal income of $98.4 million only 49% came from employment, indicating that transfer payments are an unusually large share of the economy.[16] These include all payments from governments to individuals, and in 1998, 38% of them were for health care.

There is detailed data publicly available regarding employment by industry, and it shows that the WHCA's ten largest employers are predominantly in education, or local government and other forms of public administration. Industry employment data is broadly grouped, making it difficult to conveniently estimate which jobs are primarily characterized as either basic or non-basic employment. Nevertheless, out of the need to arrive at some estimated

[16] Alaska Map Stats accessed at http://www.fedstats.gov/qf/states/02/02270.html.

representation of the strength of the local economy, the judgment is that jobs in the WHCA government sector are primarily basic. The rationale for this is that in the WHCA the low per capita income is an indication that local government requires a certain measure of transfer payments to fund operations. There is no significant tax base such as enjoyed by NWAB or NSB (resource based industry) to provide tax revenue to fund local government. Government makes up over 55% of borough employment.

**Table 7. WHCA Basic/Non-basic Employment Relation**

| Industry | 2000 Employment[17] |
|---|---|
| Mining | 0 |
| Heavy Construction | 4 |
| Transportation | 145 |
| Hotels | 0 |
| Health Services, Education, Government | 1,148 |
| Membership Organizations | 253 |
| Manufacturing | 25 |
| Basic | 1,575 |
| Non-Basic | 442 |
| Total | 2,017 |
| Multiplier = Total/Basic = | 1.28 |

Using state Department of Labor earning and employment data for 2000 and assumptions about basic economic activity, the ratio of total jobs to basic jobs was calculated as 2,017:1,575 = 1.28:1, indicating a possible employment multiplier of 1.28.

## 2.4 Nome Census Area

**Nome Census Area (NCA).** The U.S. Census Bureau boundaries around the NCA enclose a 23,013 $mi^2$ section of tundra landscape in northwest Alaska. In geographic terms, the area includes a major portion of the Seward Peninsula and a narrow southern stretch along the Norton Sound coast. The area extends west into the Bering Sea to encompass the three islands of St. Lawrence, King, and Little Diomede. Some call the entire Nome area the Bering Strait region. Seventeen communities of varying sizes are inhabited today. Savoonga and Gambell are located on St. Lawrence Island. Diomede City (Inalik) is the only community on Little Diomede Island. Nearly 16% of the NCA's population resides on these two remote islands. On the mainland, the other communities are located close to or along the coast and can only be reached by air or, during less than six months of the year, on water. During winter, frozen or snow-covered tundra permits travel by snowmobile or dog sled.

Indigenous people settled the area over 4,000 years before gold was discovered in 1900, and their ethnicity is reflected in the area's demographics. With the exception of Nome, the vast majority of the area's population, nearly 81% are Alaska Natives. Area Natives can trace their cultural roots to one of three distinct groups of Inuit (Eskimo) people. While residents on the Seward Peninsula mostly identify with the Inupiat culture, descendants of the Central Yupiks tend to live south of Unalakleet. Most Inuit people with Siberian Yupik ancestry live

[17] Alaska Department of Labor and Workforce Development database.

on St. Lawrence Island and are closely related to the Chukotska people of the Russian Far East in culture and language.

The town of Nome was founded in 1901 and became the fifth Alaska settlement to incorporate as a city. After the gold rush, several hundred settlers remained in the area. Some continued to mine gold on their own, while others worked for the more profitable mining companies. Still others developed commerce or provided services to the resident population. In spite of the harsh climate and six major catastrophes that destroyed the town (fires in 1905 and 1934, and violent storms in 1900, 1913, 1945, and 1974), residents persevered. In addition, Nome's population endured the 1918–1925 influenza epidemic and diphtheria outbreak, which helped create the notoriety of the Iditarod Trail. Every year since 1972, dog mushers have raced dog teams from Anchorage to Nome to commemorate the 1925 delivery of life-saving serum. In 1900, according to the U.S. Census, the city of Nome was the largest settlement in Alaska, with 12,488 people. Local chronicles tell that, during the summer months of 1901, this population may have reached 20,000. As elsewhere, Nome's gold rush lasted only a few summers. By 1910, its population had shrunk to 3,200 residents. In 1920, only 852 people were recorded as living in the town. However, residents did remain, and Nome is now one of the oldest commerce and trade centers in the state. In 2001, the city had 3,505 residents and ranked as the twentieth largest among Alaska's inhabited places.

**Population**. The NCA includes 16 communities besides the city of Nome. Altogether 9,413 persons live in the area.

**Table 8. NCA Population**

| Village | 1990 | 2000 |
|---|---|---|
| Nome | 3,500 | 3,505 |
| Brevig Mission | 198 | 261 |
| Diomede | 178 | 172 |
| Elim | 264 | 284 |
| Gambell | 525 | 636 |
| Savoonga | 519 | 615 |
| Golovin | 127 | 163 |
| Koyuk | 233 | 280 |
| St. Michael | 295 | 351 |
| Shaktoolik | 178 | 231 |
| Shishmaref | 456 | 537 |
| Stebbins | 400 | 507 |
| Svoonga | 519 | 643 |
| Teller | 151 | 278 |
| Unalakleet | 714 | 798 |
| Wales | 161 | 152 |
| Total | 8,418 | 9,413 |

**Employment and Income**. Within the census area, Nome is the largest city and functions as the commercial center and transportation hub. It also houses numerous government offices, and government is the largest employer. Of the total employment in the census area 3,497, some 40% were in government and most of those in Nome proper. Unlike the small villages scattered around the census area, Nome has a more diverse population in the sense that it has a population that is made up primarily by 42% non-Native persons and 58% Natives.

**Table 9. NCA Employment And Earnings**

| Industry | Average Annual Monthly Emp | Yearly Earnings ($) | Monthly Earnings ($) |
|---|---|---|---|
| Total Industries | 3,479 | 97,092,470 | 2,326 |
| Private Ownership | 2,093 | 55,375,468 | 2,205 |
| Total Government | 1,387 | 41,717,002 | 2,506 |
| Ag, Fishing & Mining | 8 | Not disclosed | |
| Construction | 45 | 1,354,187 | 2,508 |
| Manufacturing | 31 | Not disclosed | |
| Trans, Comm, and Utilities | 302 | 8,196,965 | 2,262 |
| Wholesale Trade | 15 | | |
| Retail Trade | 412 | 7,431,854 | 1,503 |
| Finance, Insurance & Real Estate | 270 | 5,783,605 | 1,785 |
| Services | 1,010 | 31,588,711 | 2,606 |
| Total Government | 1,387 | 41,717,002 | 2,506 |
| Federal Government | 81 | 3,184,452 | 3,276 |
| State Government | 197 | 10,102,325 | 4,273 |
| Local Government | 1,109 | 28,430,225 | 2,136 |

The NCA economy is somewhat different from other parts of the study area particularly due to the role of Nome as a distribution center that is accessible by commercial vessels that use a causeway as a load transfer station. Nome also has a protected harbor for a fleet of fishing vessels. With two airports it is also an air transportation hub. As a result of the commercial center and related supporting infrastructure not available in the smaller communities, within Nome proper, there is more of a balance between basic and non-basic employment.

Nome, however, includes only about a third of the census area population, and by the time the rest of the jobs are blended into the larger area population, the mix is not overtly different from other rural Alaska boroughs. The distinction between basic and non-basic employment is equally blurred for the NCA, as it is for the others, although the higher median family income at $68,800, compared to say NWAB at $42,200, would indicate higher earning jobs at Nome. This would indicate that basic employment is more prominent in the economy of the NCA than NWAB for example.

The jobs that are more clearly defined as non-basic jobs are in trade and services making up 42% of the total. With a non-basic sector consisting of 42% of the employment, the local economic multiplier is larger for the NCA than the other parts of the study area. The indicated multiplier is estimated at 1.7.

## 2.5 The Yukon-Koyukuk Census Area (YKCA)

**The Yukon-Koyukuk Census Area (YKCA).** The YKCA covers most of Alaska's interior region. It covers 48,258 mi$^2$, over a quarter of Alaska's landmass and is larger than the state of Montana, the nation's fourth largest state. Because it's geographic boundaries do not surround a square land parcel or follow a river, like the other census areas and boroughs, the area is difficult to describe. Since it is unlikely that the economic effects of the recommended project will be identifiable at points east of Galena on the Yukon River, only the westward portion is treated as being within the study area.

Regarding a description of the entire census area, the northern boundary runs south of the Brooks Range, and Canada's Yukon Territory lies to the east. The southeastern boundary separates YKCA from the areas which comprise the remainder of the Interior region: Southeast Fairbanks Census Area, and Fairbanks North Star and Denali boroughs. The southern border turns due west to the village of Holy Cross, the area's southwest corner. From there, the western border runs through the Nulato Hills. The outward edges of the Endicott Mountains form the area's northwestern outline.

Five national wildlife refuges and several mountain ranges lie within the YKCA, and the Yukon River roughly bisects the area, flowing approximately 1,100 miles through it in a southwesterly direction. Five of Alaska's ten largest rivers are tributaries of the Yukon, ranging between 314 and 555 miles in length. The Kuskokwim, Alaska's fourth longest river, also has its origin in this area.

**Population**. Only 6,372 people reside in the census area, and 63.3% of the population is Alaska Native. Most settlements are located on the Yukon River or its tributaries, but there are only seven villages in the YKCA that are within the study area. In the entire YKCA there are only seven settlements that are on Alaska's road system, but all seven are well outside of the study area. Either boats or airplanes must be relied on to provide a year-round connection to Fairbanks and other places from study area communities. The seven villages that are within the study area receive seasonal freight delivery by river barge and are situated in remote Yukon River locations.

Little commercial interaction occurs among the villages in the YKCA because of the vast geographic distances and general isolation. Most supplies and services are dispatched from Fairbanks, the interior's urban center, or are delivered from the river mouth, having originated in Puget Sound communities or Kenai Peninsula area of Alaska. Of the seven water delivered villages in the YKCA that are in the study area, Galena is the largest with a population of 675.

**Table 10. YKCA Villages In The Study Area**

| Village | Population 1990 | Population 2000 | Employment 2000 |
|---|---|---|---|
| Anvik | 82 | 104 | 29 |
| Shugeluk | 139 | 129 | 45 |
| Grayling | 208 | 194 | 52 |
| Kaltag | 240 | 254 | 69 |
| Nulato | 359 | 336 | 74 |
| Koyukuk | 126 | 101 | 40 |
| Galena | 833 | 675 | 334 |
| Total | 1,987 | 1,793 | 643 |

**Employment and Income**. The economy of the Yukon-Kuskokwim area cannot generate all the cash it requires, and subsidies, whether in kind or cash, are needed. The infusion of public funds into the region is relatively large. Despite public subsidies, village residents enjoy few modern conveniences. Life is very basic, and subsistence plays a major role.

Until recently, gold mining, commercial fishing, and trapping were part of the region's cash producing economies. The rich mineral deposits of the interior are legendary. Many settlements cite a gold rush in their chronicles and have contributed to Alaska's turbulent gold mining history. In recent history, rich gold deposits warranted the construction of two mines. The Illinois Creek Mine, near Galena, and the Nixon Fork Mine, north of McGrath, built in the mid 1990s, had a combined production potential of nearly 80,000 ounces of gold per year. But both mines, operating in high cost environments, had to suspend operations when gold prices started to deteriorate in 1998. Placer mining operations also fell victim to unfavorable business conditions.

The lack of employment opportunities remains a basic characteristic of rural Interior Alaska. Year-round employment is rare. Villagers often have to leave their communities to take jobs elsewhere. Construction work and fire fighting are examples of such seasonal jobs. Therefore, it is not surprising that many people of working age leave the villages, and this appears to be happening in the YKCA; the working age population (18–64 years of age) declined 6% between 1990 and 1999. Net migration figures confirm that fewer people come into than leave the area. In fact, the overall population has declined in most years of the 1990s, and natural increase from births could not offset this trend. Despite its rich mineral resources and natural beauty, economic development is a challenge for most of the YKCA because of limited access and vast distances.

Residents of the YKCA share a common lifestyle and similar economic activities. Subsistence hunting and fishing remain a vitally important part of the economy and way of life. Delivery of supplies and services to residents is the main ingredient of the cash economies. Airways are the most used link for travel and supplies. Typically, village infrastructure is modest, although most inhabited locations have an airstrip. Basics of modern living such as indoor plumbing or piped-in water are still considered amenities here. The region is rich in mineral deposits, but like other remote Alaska locations, transportation systems needed to extract and market mineral deposits are lacking. The public sector plays the role of lead employer. Job opportunities in all the remote communities are few, and regional income is low.

During the past eight years, employment grew by 113 jobs, or six percent for the entire YKCA; however, government remained the dominant employer, claiming more than half of all payroll jobs. Although the public sector maintained its dominance, it did suffer substantial job losses when the Air Force Station in Galena closed. In 2000, government jobs made up 60% of the YKCA total wage and salary employment. Federal and state government employment was fairly small, but local governments, including school districts, employed nearly half of the entire wage and salary workforce.

City and village government entities employed almost 370 of the 643 workers. Most of the rest were school district employees, making public education the leading economic force. Five school districts operate in the YKCA, and all of them are on the list of largest employers. Within the study area, the Galena City School District is the largest. In addition to its regular school and a boarding school for high school students, this district runs a popular cyber school. Two other local districts, the Iditarod Area and Nenana City Schools, also offer long distance learning programs.

The Interior Long Distance Education Area (IDEA) branch of the Galena City School District is the region's most popular education program, although only 10 students in the YKCA are using it. In October 2000, IDEA enrollment reached nearly 3,100 students, down from its record high of 3,487 in 1999. This new education format offers home schooling programs from kindergarten through 12th grade.

Important employers include the local tribal councils that provide housing, health care, and other social services to residents. These councils perform services under contract with non-profit organizations or government entities, so in essence, public funds from outside the region support their effort. The retail sector had the second largest employment count in the area, but retail jobs are generally low paying and are located in larger places, such as Galena, and the small villages typically have only one variety store. The transportation industry is also very important with most jobs airline related.

The various income accounts for the YKCA show earnings falling considerably below state averages. Average wage and salary income in 2000, for example, was more than 25% below the statewide average. Personal per capita income for 1998, pointed to a 35% difference. In 1997, household income ranked 25th among Alaska's 27 census areas. Median household income was $30,532, trailing the statewide median by 30%.

All measures show widespread poverty in the area. The U.S. Census Bureau recently published its 1997 poverty estimates, concluding that 24.2% of residents of the YKCA were living in poverty. This is more than twice the statewide rate of 11.2%. Statistics also show that earnings have declined in recent years. Total payroll earned in the area has decreased from $65.4 million in 1995 to $52.9 million in 2000. Some of the decline relates to the mine closures at Illinois Creek near Galena, and the Nixon Fork Mine, which was located north of McGrath. The size of the drop in total personal income figures was held to $1.1 million between 1995 and 1998, because two of its components, transfer payments, and dividends, interest, and rental income, rose in the same time period.

Personal income in the YKCA is made up of dividends, interest and rent 15.0%, transfer payments 36.3%, and net earnings 48.7%. More than 38% of the area's government payments were spent on behalf of the resident population for medical services. Alaska's Indian and Eskimo populations receive free health care benefits under Federal mandate.

The second largest transfer payment category, claiming nearly 24%, is the class of payments that includes the Alaska Permanent Fund dividend distributions. Since 1995, those payments rose by 32%, most of which reflects the increase in the amount of Permanent Fund dividend checks. Income maintenance benefits payments, which include family assistance, food stamps, and other assistance, made up nearly 22% of the transfer payments. The remaining 16% of transfer payments were unemployment insurance, retirement, disability payments, and disbursements to nonprofits, businesses, education, and training programs.

Of the ten largest employers in the entire YKCA, number one and number ten are in the study area at Galena. They are the Galena City School District with 148 employees, and the City of Galena with 41 employees.

**Subsistence**. Hunting and fishing are the traditional sources of food. They are basic to the rural economy; area grocery prices are among the highest in the state. Transportation charges to these remote and sparsely populated settlements are high. In the YKCA, subsistence centers mostly year around on fish and big game. The Yukon and its tributaries provide fish, although the salmon resource has seriously declined. In 1999, the subsistence chinook and chum salmon harvest yield was just 58% of the 1990 catch. Still, the 1999 harvest, albeit small, produced over 1.3 million pounds of fish for local residents.

Commercial fisheries harvests began in 1978 in the Upper Yukon area and developed into roe fisheries. Typically, commercial harvesters extracted and sold only the roe, mostly of female chum salmon. Though not substantial, this type of fishery produced some income for residents of the region. In 1990, for example, it earned over $2.4 million for 116 local permit holders. Recently, poor fish runs created uncertainty about the viability of such commercial activity. In 1999, earnings amounted to just $210,300 for 37 permit holders. During the 2000 season all commercial fishing ceased on the middle and upper Yukon, because the salmon run fell to record low levels and was not allowed at all in year 2001. Harvest data for 2002 and 2003 indicate a recovery may be under way, although the commercial harvest in 2003 was only about a third of what would have been expected a decade before.

Big game is another important subsistence resource. Moose, caribou, and black bear are among the most important species. Recently, the Alaska Department of Fish and Game conducted a sub-regional subsistence harvest survey for the Middle Yukon/Koyukuk area. It showed that hunting success from April 1999 through March 2000 yielded 413 moose, 137 caribou, and 62 black bear for a resident population of about 2,130. Not all households hunt, and meat is usually shared among the members of a family unit or village.

The frontier economy also includes trapping, Alaska's oldest commercial activity. Most trappers use snow machines to run their trap lines, which in the Interior average 44 miles in length. Only a few trappers still use dog teams. According to a Department of Fish and Game report, lynx, beaver, and wolf were the top species harvested in the Interior during the 1998–1999 seasons. Effort, however, has diminished because the demand for furs has dropped off sharply during the past decade.

Villages on the Yukon River have seen a rise in visits from travelers, many of them, tour boat passengers or canoeists stopping for short visits. Sport hunters and anglers regularly visit the rural Interior. Outfitters from urban Alaska, however, organize the big game hunts, and only a few local residents work as guides. This also holds true for the boat charter business. According to the Commercial Fisheries Entry Commission, only 37 of the 134 charter boats that operate on the Yukon and its tributaries are home-ported in villages of the Yukon-Koyukuk. Although the tourism industry is growing, it has not yet become big business in the rural areas of the Interior.

Although the land area common to the YKCA is huge, the population within the study area is only 1,793 people. It is clear that the villages are small and widely dispersed throughout an area lacking a road system. Unusual for an area as large as the study area, lack of employment opportunities places the population at reliance on transfer payments. This is a major source of cash with which to order goods and services, most of which are delivered from outside.

The seven villages in the YKCA that are within the study area do not constitute an economic system in the sense there is neither trade among the villages or exports from them. Given the isolated nature of the villages, the sparse economy, and paucity of economic data, estimating a multiplier serves no useful purpose and could even be a misleading indicator at a very low level of reliability.

## 2.6 Estimating Economic Effects In The Study Area

**Direct Income Effects.** Within the study area there are three examples of Alaska communities that are regional centers: Barrow, Nome, and Kotzebue. These communities share five general characteristics:

- Moderate population size of diverse structure
- Regional transportation node
- Center of regional government
- Center for educational facilities
- A greater reliance on a cash economy and lesser reliance on wild resource use compared to satellite villages

As regional centers the three communities provide services, government, commerce, and transportation for a geographic region containing a group of smaller communities. For example, according to principles involved in the transportation industry at Kotzebue, water links through Kotzebue serve nine communities in the Chukchi Sea, Kotzebue Sound, and Kobuk River area, all within the NWAB. The nine villages are Ambler, Buckland, Deering, Kiana, Shungnak, Kobuk, Kivalina, Noorvik, and Selawik. One village, Noatak, is served by air.

The strong interdependency between each regional center and the villages which are satellites to it indicate that as the cost of goods rises or falls at the location of a regional center that the cost of these goods will rise or fall at least as much to the end user in the satellite village. The economy at the level of the regional centers has a more identifiable structure, partly because economic data is more readily available for larger communities, but also because smaller remote villages do not have the critical mass necessary to support a viable, integrated, and diverse economy.

The one benefit category of this feasibility report is reduced fuel cost, which is anticipated to create the potential for economic gains at the level of the regional center and a flow through to the end user at the level of the satellite village. The total equivalent annual transportation cost savings for fuel delivery are $11,002,400. Separating the total annual savings for the mine and the villages indicates about $5,984,400 of the savings will accrue to end users at regional centers or satellite villages, assuming it is passed on.

There are other income effects that result directly from the project but which are not treated as regional impacts to the study area. The major such economic effect is the transportation savings which accrue primarily to TCAK and the shipping company employed by them. This economic saving amounts to $19,527,300 in equivalent annual terms. The reason that this gain is not considered to be an impact of the study area is that the companies which receive the benefit are corporate business structures with diluted ownerships. Few if any shareholders are likely to be residents of the study area; it is ultimately the shareholders that receive the economic gain derived from increased net earnings. Therefore the actual transportation benefit that appears to flow to TCAK is in reality a benefit disbursed among shareholders. In the year 2000 there were 85,569,806 common shares.

**Direct Employment Effects.** Directly related to the project operation and maintenance, there will be a reduction in employment at Portsite. This is due to replacement of the self-unloading barges and part of the local tug fleet with a conveyor loading system. Tug and barge operations require 24-hour staffing during the shipping season, and therefore, require onsite labor plus catering. Catering includes accommodations, meals, recreation, and ancillary support.

The reduced number of personnel resulting from partial replacement of the dedicated tug and barge fleet is partially offset by new jobs created for management and maintenance of the conveyor loading system and the fuel loading operation. All of the affected positions are seasonal jobs. A summary comparison of direct operation and maintenance employment in the without-project condition and the recommended plan is shown below:

**Table 11. Direct Operation And Maintenance Employment For Activities Affected By The Recommended Plan**

| Activity | W/O Project | With-Project | Difference |
|---|---|---|---|
| TCAK | 10 | 14 | +4 |
| NANA | 4 | 2 | -2 |
| Tug/Barge/Other | 30 | 15 | -15 |
| Fuel Shipper | 0 | 2 | +2 |
| Customs | 0 | 2 | +2 |
| USCG | 0 | 2 | +2 |
| Catering | For 44 personnel | For 37 personnel | -9 |
| TOTAL JOBS | 44 | 37 | -7 |

**Indirect Employment Effects.** Essentially any transportation savings from the project that is passed along to end users within the study area has the same affect as an infusion of new effective demand would have. For example it would be as if each end user of fuel received a savings and treated that savings as an increase in disposable income equivalent to the amount saved in the fuel bill. This would result in an expansionary effect in that it allows the end user to act on his needs for additional goods and services by virtue of the fact that disposable buying power is increased. To the extent his increased disposable income is spent at the local level, it works to boost the local economy. This active re-spending of disposable income at the local level is referred to as having a multiplier effect. In a sense, the spending of a dollar is multiplied if the recipient of the first round of spending uses it to purchase other goods and services locally as well.

The makeup of the rural Alaska economy is such that the multiplier effect is at a minimum for most of the locations in the study area. This is because trade patterns indicate that expanded purchasing power such as might happen from a reduced fuel bill is largely spent outside of the local economy to import goods and services not locally available. This leakage of purchasing power is to the detriment of the local economy. Employment multipliers have been estimated for parts of the study area as follows:

**Table 12. Employment Multipliers**

| Region | Employment Multiplier |
|---|---|
| NWAB | 1.27 |
| NSB | 1.25 |
| NCA | 1.7 |
| WHCA | 1.28 |
| YKCA | Not estimated |

It is possible to derive the fuel savings for each of the parts of the study area from the benefit evaluation in this report and then to use the savings per locality to estimate the equivalent employment effect it might deliver by using the above multipliers. Being interested primarily in overall study area effects, however, locality specific data was combined generating an arithmetic average of the four multipliers: 1.37.

This composite multiplier is used to estimate the potential employment effect that a reduced fuel cost to the end user might have on the study area. The direct effect is treated as a demand shift (comparable to purchasing power that is created by new transfer payments) and the employment multiplier is used to guide the estimate of jobs created. The estimated number of jobs created is very sensitive to what one assumes to be the average wage and the fully burdened labor cost. In the following example the average wage is varied from a low of $19,740, based on the average of non-basic jobs in the NWAB, to a high of $66,400 for basic sector jobs.

While wages are a reflection of individual productivity, they are not a measure of labor cost as a factor of production, because they do not include the fully loaded cost. The cost to a company of having a staff member work for an hour is not that person's hourly rate but also includes the cost of benefits such as sick leave, training time and cost, vacation time, facilities costs such as office space, heating and cleaning, computers, indirect staff support such as office administration, personnel management, direct supervision, parking areas, payroll tax contributions, etc., and the many other costs associated with having that person employed.

Thus, the theoretically correct way to account for the cost of employee time is not the *average* cost of the employees' time but the *marginal* value of their time, necessitating the use of a so-called hedonic wage model. For practical purposes, however, it is rare that marginal values are known or even easy to estimate, so it is quite common to use average loaded values. The simplest way to derive the average loaded cost of an employee is to count up total corporate expenses and divide it by the total number of productive hours worked. The point is to not count time spent on training seminars, lunch breaks, and similar activities that may be necessary but do not generate output. Commonly, the fully loaded cost of an employee is at least twice his or her salary. Lacking case specific data on the relation between salary cost and employee loaded cost, the following example based on the cost of employees in a Federal agency is used as the norm.

| | |
|---|---|
| Base Salary | 1.00 |
| Effective Rate Factor | 48 |
| Department OH @ .43, so (1.48 x .43) = | .64 |
| G&A OH @ .27, so (1.48 x .27) = | .40 |
| Total Labor Multiplier | 2.52 |

Recognizing the importance of including the labor burden, the range of employment impacts is estimated by:

($5,984,400[18] final demand change x .37 employment multiplier)/($19,740 x 2.52) ♎ ($66,400 x 2.52) estimated average wage per non-basic sector job = lower bound potential of 13 created jobs and an upper bound potential of 44.

Employment impacts directly on personnel involved the fuel handling are anticipated to be insignificant since the total volume of fuel delivered is not changed and the type of equipment used is unchanged although there is anticipated to be some adjustment of time and location of labor needs and equipment use. The estimated number of study area jobs created as a result of lower fuel cost is 13–44.

[18] This represents a final demand change in disposable personal income equivalent to annual fuel cost savings realized by village residents. See page 221, Table 82, for a summary of fuel savings.

# 3.0 COMMODITY PROJECTION

**Purpose and Findings**. The purpose of this section of the economic analysis is to substantiate estimates of potential commodity shipments through Portsite for mineral concentrates outbound, and fuel and general cargo inbound. A general finding is that, over the planning period, mineral concentrate tonnage is stable and practically equivalent to the without-project condition. Over the planning period, regional fuel needs are also stable and are anticipated to be practically unchanged by the project; however, in the with-project condition fuel destined for surrounding villages would be delivered through Portsite as the least cost route.

This section describes the basic shipping scenario under conditions with no shipping constraints in order to reveal the nature of transportation investment needs that could arise at Portsite out to year 2061. It is intended that the commodity projection be used in connection with the following:

- As verification of the fundamental aspects of the benefit-cost analysis by demonstrating that the extractive resource base of the region is adequate to sustain a commodity flow.
- As a statement of transportation needs thereby explaining problems in the without-project condition.
- As a demonstration that projected future shipments are economically viable.
- As an indication of the consistency of Portsite alternative plans with long-term regional and NED objectives.
- As a comparison of the timing and number of tons shipped, without any planned Portsite improvement, against the timing and number of tons shipped with various plans of improvement.

**Methodology**. Zinc concentrate is the major commodity to be shipped. It is the fundamental purpose for the Red Dog Mine being developed, and it is the major commodity that has been shipped each year since the mine was opened. Lead concentrate is a secondary output and shipments of both commodities have grown from 191,981 swt of zinc and 31,187 swt of lead concentrate in 1990,[19] to 1,100,000 swt of zinc and 177,855 swt of lead concentrates in 2001,[20] and 1,209,000 swt of zinc and 200,100 swt of lead concentrates in 2002.[21] Lead and a small amount of silver is a byproduct of the zinc operation, in the sense that without the large quantity of zinc, extraction of other metals would not be profitable.

Lead represents about 14% of the commodity movement, although a far lesser percentage of mine revenue being practically a break-even commodity. It is an important industrial metal on a worldwide basis; however, it is not a basic reason for the Red Dog Mine, merely a byproduct, and the world lead supply has changed little over the last several decades with few if any new lead mines. In the future, most lead will be produced as byproducts of zinc

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[19] Draft Resource Transportation Analysis, Phase 1-Program Definition, table 2-1, prepared for Alaska Department of Transportation and Public Facilities, April 2001 by Ch2M Hill and Associates.

[20] Personal communication, January 2002, Bob Jacko, General manager, Teck Cominco Alaska.

[21] Minecost model, Excel spreadsheet, production tab accessed at Minecost.com.

mines and recycling of batteries. Its main use is in lead-acid batteries, accounting for 70% of demand, followed by glass, ammunition, and ceramics.

Potential lead emissions to the environment are a significant environmental and human health issue. For this reason, long-term onsite storage of lead produced at Red Dog is not an option. This is an incentive to ship lead even when market prices are low, and it is not practical to consider de-bottlenecking of Portsite by avoiding the shipping of lead. The nature of it being a byproduct of the zinc process and the commitment to ship it are the reasons that the projection methodology centers on trends in the supply and demand for zinc only.

From Red Dog, zinc concentrate is shipped to destinations on the Pacific Coast of North America, to Europe, and to Asia. There is clearly a world market to address, so the projection methodology looks primarily at the future of zinc in a world wide frame of reference. This starts by a broad appraisal of ore resources near Red Dog as a basis for showing short-term and long-term viability of the mine and the port, in three time frames (2004–2011, 2011–2042, and 2042–2061).

In the longest term it is anticipated that increasing cost and declining resources will see Red Dog zinc becoming less profitable. Providing that costly large scale transportation infrastructure developments take place, it is possible that increasing amounts of other commodities such as coal and copper could be shipped through Portsite. To date, however, there has been no indication of the economic viability of such infrastructure. Mineral projections for the longest term (2042–2061) are not included in the benefit-cost evaluation of proposed improvements to Portsite, because there is no evidence at present that the needed transportation infrastructure is economically viable and environmentally acceptable and because profitable extraction of at-site resources are foggy beyond the forty-year horizon.

After discussing an expected short- and long-term need for zinc, based essentially on its value as a galvanizing agent in a growing world economy, a range of future production is estimated. Following that, the methodology uses a cost simulator to construct a supply curve of all western world zinc suppliers to demonstrate that Red Dog is at a place low enough on the supply curve that it will remain viable during downturns in the world price structure. The cost curve is also used to support that there is a huge market potential being served by mines that are more costly than Red Dog. This allows the conclusion that the output of Red Dog spans a wide range of sales options, which the company manages in a way that frames a fairly narrow band of projected tonnage.

The methodology herein depends to the maximum extent on gleaning data from existing studies. It borrows from numerous databases and reports, and therefore, mixes together numerous unstated assumptions, methods, time frames, and motives. To some extent it relies on judgment and non-quantitative scenarios especially where long-term aspects of the world economy are an issue. The resulting world level projections are a compendium of estimates, which serve only to demonstrate that the envelope of commodity shipments that bound Red Dog are so huge that it is ultimately a mix of profitability, resource availability, and resource quality that determine the number of tons available to be shipped.

**World Zinc Outlook**. Zinc will be the primary product from the Red Dog Mine. Other products will be lead and silver ore, which separate during the process used to concentrate zinc ore prior to shipping. Zinc's most remarkable quality is its natural capacity to protect.

By protecting steel against corrosion, zinc protects buildings, automobiles, ships, and steel structures of every kind from corrosion by the atmosphere, water, and soil. Galvanizing is the process by which zinc is bonded to steel, thereby giving the steel the most advanced and cost effective anti-corrosion coating.

Economic loss due to corrosion is estimated to cost 4% of the U.S. gross national product every year. By protecting against corrosion and decreasing the need for maintenance and replacement, zinc extends the life of steel, thus protecting investments and saving natural resources and energy. A typical galvanized coating can now be expected to last 25–50 years without maintenance in most urban and rural environments. Zinc can be a life-saver in the event of a fire, because unlike many other materials, zinc-coated, unpainted steel does not give off toxic fumes.

Zinc is mixed with copper to form brass and is used in batteries, tires, paints, and other preservatives. Zinc is essential to living organisms, including humans. It is also used in sunscreens and in ointments formulated to treat rashes.

Based on world wide consumption data for 1997, 48% of all zinc goes into galvanizing, 18% goes into making brass, and 14% goes into the making of die castings. These three end uses represent 80% of all zinc consumed annually.[22] Most of the zinc consumed in the U.S. is used in the metal plating process, and according to United States Geological Survey (USGS), about 55% of the annual use is related to the automobile industry.[23] This is an important link, because production of the automobile industry appears to be closely related to growth in economic prosperity. Most of the balance appears to be used in other consumer products giving additional support to the proposition that any future projected increase in zinc demand might be revealed by expectations of future increases in prosperity, and to a lesser extent, population. This apparent overriding relationship to trends in prosperity is supported by a look back at zinc consumption, population growth, and industrial output.

Because many products made from zinc or protected by zinc have a long life, the interval between consumption of zinc for making a product and its return into the recycling circuit as scrap is thought to be well in excess of 25 years. In spite of this, every year 2 million tons or 30% of the world zinc supplies come from recycled zinc. This is approximately 80% of the zinc available for recycling.

**Zinc Projection.** It is the business cycle that drives fluctuations in the rate of production and consumption of zinc, and the cycles vary in length from 1–9 years by most accounts. The business cycle dictates how much users will demand and how much suppliers will produce. The continual interaction of supply and demand is the principal factor determining price, and this holds true both for the present, the immediate future, and the long-term future.

In the short-term (1 month–2 years) downward adjustments in the world zinc demand can be accommodated by higher cost individual suppliers cutting back on production. For upside adjustments, in the short-term it is not practical or possible to expand mine capacity by capital additions, so production needs are met by more intensive production schedules or

[22] Zinc Market, Price and Treatment Charge Outlook, Prepared for AIDEA by Brook Hunt, 1998.

[23] Personal communication with Jozef Plachy, USGS Zinc Commodity Specialist, also Materials Flow of Zinc in the United States 1850-1990. OFR 72-92, U.S. Dept of Interior accessed at http://pubs.usgs.gov/usbmof/ofr-72-92/ofr72-92.pdf.

ramping up marginal mines and smelters. These short-term production decisions are reviewed daily within the industry, because the world metals situation changes daily, and the prospects for short-term loss or gain can have serious consequences if not managed strategically.

If longer term upward and downward adjustments to the market appear necessary, plant closure and increments of capital investment are considered. Cutting back on the overall supply might require the shut down of individual facilities to minimize costs that might otherwise continue regardless of production levels. On the upside, accommodation of long-term expansion plans requires adding mine, concentrator, and smelter capacity. Any commitment to these potential longer term scenarios requires significant lead time coupled with a long-term planning horizon.

Some industry conferences have addressed the zinc market supply and demand issues looking out 5–10 years. By the year 2010, Brook Hunt, a minerals forecasting institute in England, predicts that the demand for zinc will exceed supply. To meet the demand between now and 2010, up to 2.5 million tons of capacity will need to come online just to keep up with demand.[24] Studies such as those made by Brook Hunt and others are sophisticated well informed applications of the best available knowledge, and they are considered by other analysts to be reliable and well documented. Like other studies they contain numerous assumptions, caveats, and conditions not disclosed here due to the overview, long-range, nature of this discussion.

There are a number of trade journals, consultants, and industry work groups that review economic activity in the metals industry daily, weekly, and monthly. They are interested in the short-term fluctuations of the available supply for purposes of planning their production and positioning themselves in the market. Such short-term evaluations are directed towards managing existing plant capacity in a way that maximizes net income. One must look beyond the next few years to make sensible capital expansion proposals; however, such publicly available long-range studies are practically non-existent. There are no known publicly available 50-year projections of either supply or demand for zinc.

In this report, effects of the day to day market adjustments and the typical business cycles ranging from 1–9 years are avoided in favor of developing an estimated long-term "average" growth rate. Although it is generally accepted that future trends in zinc production will be largely influenced by needs of emerging economies, one's views of such international economic and political developments depend heavily on assumptions one is willing to make about the future. For example there are two somewhat extreme scenarios generally accepted by futurists, but while being at extreme variance with one another, they are equally valid since they are a matter of individual imagination and individual preference. The polar conditions are typically described as a Fortress World and an Economic World, and as the names imply, they represent a range from extreme isolation and hardship, to prosperity and well being. The influence of ones assumptions about the future can be tested using interactive programs that apply the assumptions to generate 50-year projections of economic,

[24] The Zinc Mine-Smelter Interface: Investment, Integration And Implications For The Concentrate Balance, Speech to Metal Bulletin Conference, Dublin, May 2000. Chris Parker, Zinc Mine Analyst, Brook Hunt.

environmental, political, and social trends. One such interactive program inviting individuals to enter their assumptions is useable through the Internet.[25]

There seems to be a general agreement among industry experts that galvanizing of steel will be the fastest growing end-use. Since the mid-1980s the penetration of galvanized steel sheet into automobiles in the developed economies has provided enormous new market opportunities for zinc. Car manufacturers, seeking to improve the quality and competitiveness of their vehicles, moved in the mid-1980s in the North American vehicle market to provide anti-corrosion warranties for new vehicles. This practice spread rapidly to other markets, notably Western Europe and to other auto-producing countries, Japan, Korea, etc., which sought to export vehicles to these markets. The construction industry in the developed world is also seeing increased use of galvanized steel for a number of reasons. The cost of repainting structural steel during the life of the structure is higher than using higher cost galvanized steel in the original construction phase.

Vehicles represent about 55% of zinc use and the fact that vehicle ownership is higher in western countries indicates that vehicle replacement will be high as well. There is a high per capita ownership of motor vehicles and consumer durable goods already in the western economy, but contrary to some views, this is not a sign that future growth will slow because replacements are essential.

Some analysts believe that the largest absolute gains in zinc and lead usage will occur in Asia. Its large population and expected growth in per capita incomes will encourage investment in infrastructure (power distribution and generation, roads, telecommunications) and growth of domestic auto and consumer goods industries. Other zinc end-uses, in die-casting and oxides, will see rapid growth too, in line with the expansion in industrial output and the growth of the world's vehicle fleet.

In the short-term, several industry sources estimate that zinc demand globally is anticipated to grow by as much as 3.3% per annum over the next five years. Developed economies will see growth of 1.8%, and emerging economies, a zinc demand growth of 5% per annum. Chinese demand is expected to expand by well over 6% per annum. To meet this global forecast, zinc demand growth of 3.3%, in new supplies of zinc, will be required.

China is now the world's largest producer of mined and refined zinc. In reaching this position, China alone accounted for 28% of gross new mine capacity added globally during the 1990s. And, after allowing for the loss of capacity through closures, the increase in Chinese mine output during the last decade amounted to 58% of the total net increase in global mine output. Thus, meeting increased demand for zinc during 1990s was effectively accounted for by China plus the major western world mining houses. There is some concern now that the requirement for new mine capacity over the next five years cannot be met in the same way. Major western zinc mining houses now have a much smaller involvement in new projects than was the case during the 1990s. At the time of this writing, there are new projects coming on stream, which are in the portfolios of major companies: Antamina in Peru (Teck, Noranda, Billiton), which will produce, close to 300 kilotons annually, of zinc concentrate; Francisco Madero in Mexico (Peñoles), which will produce up to 130 kilotons

[25] http://mars3.gps.caltech.edu/whichworld/explore/trends.html.

annually; Pend Oreille in the U.S. (Cominco) some 50–55 kilotons annually; and Skorpion (Anglo Base Metals, a division of Anglo American) at 150 kilotons annually. However, these mines do little more than compensate for capacity losses, resulting from the closure of other mines, due to reserve depletion.[26]

Over the time-span 1998 until year 2015, there are anticipated to be closures taking about 4.5 million tons of zinc capacity out of production annually. This will be partially made up by new mines adding about 2 million tons from known deposits.[27] Even a zero growth scenario would conclude a zinc deficit is inevitable, thus creating pressure on zinc prices and spurring explorations.

Some rise in Chinese zinc mine production is expected over the next couple of years, but sustainable supplies from very small-scale operations are the most likely event. There is no major zinc mine expected to come on-stream in China in the next two to three years, and the growth of new zinc mine capacity in China is likely to slow considerably from the increase seen in the 1990s.

From 2003–2004 industry sources estimate that the world zinc market is likely to move into deficit,[28] even with some additions to zinc smelting capacity in China and in the western world (the most in the latter being the expansion of Cominco/Marubeni's Cajamarquilla operation in Peru). But the critical issue then becomes whether there will be adequate supplies of zinc in concentrates to feed these expansions.

At the start of a new century, poverty remains a global problem of huge proportions. Of the world's 6 billion people, 2.8 billion live on less than $2 a day and 1.2 billion on less than $1 a day. Eight out of every 100 infants do not live to see their fifth birthday. Nine of every 100 boys and 14 of every 100 girls, who reach school age, do not attend school. Poverty is also evident in poor people's lack of political power and voice, and in their extreme vulnerability to ill health, economic dislocation, personal violence, and natural disasters. And the scourge of HIV/AIDS, the frequency and brutality of civil conflicts, and rising disparities between rich countries and the developing world have increased the sense of deprivation and injustice for many.

The World Bank's, <u>World Development Report 2000/2001: Attacking Poverty</u> (which follows two other World Development Reports on poverty, in 1980 and 1990) argues that major reductions in all these dimensions of poverty are indeed possible; the interaction of markets, state institutions, and civil societies can harness the forces of economic integration and technological change to serve the interests of poor people and increase their share of society's prosperity.

Against this general outlook is a consensus that wealth will grow faster than population over the next 50 years as the most disadvantaged nations began to surge forward economically.

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[26] Portions of this discussion were adapted from a copyrighted presentation prepared by CHR Metals Limited, and delivered at Xiaoshan, China; *A Five-Year Outlook For The Global Lead And Zinc Industries*, by Claire Hassall and Huw Roberts, March 2000, with the permission of CHR Metals.

[27] Expatriate Resources accessed at http://www.expatriateresources.com.

[28] International Lead and Zinc Study Group accessed at http://mars3.gps.caltech.edu/whichworld/explore/trends.html.

Consistent with this anticipated growth in per capita wealth will be a continual need for development of new resources to keep up with world needs.

In this report the long-term growth rate for zinc production is based on an interpretation of growth in zinc production over the last 50 years. The 50-years, looking back, includes world wars, numerous conflicts and political realignments, the birth of new nations, the disappearance of a cold war, world wide technological revolutions, NEPA, NAFTA, atomic energy, nuclear catastrophes, and explorations beyond planet Earth. It also includes changes in the way zinc is used, what it is used for, and what is substituted for it. What will happen in the next 50 years may well be as inconceivable now as personal computers, organ transplants, genetic engineering, and walking on the moon were in the 1950s.

An examination of the relationship between per capita income and zinc production among thirteen countries showed a reasonably strong correlation between per capita income and zinc demand. However, there is no adequate, consistent, uniform, verifiable means of documenting world wide historic measures of wealth, and there is an absence of well developed models suitable for generating long-term projections of it. In contrast, acceptable data relating to historical population is available as are population projection models. This lack of balance between the two basic parts of the per capita income estimate weakens the confidence one has in developing or using world projections of per capita income. Nevertheless, this report presents the proposition that economic growth equivalent to that of the last 50 years will be added during the next 50 years and looks to historic population and income data to supply parameters for the proposition. This interpretation of the past creates a view of the future, which represents a slowing of growth rates, because the amount of historic growth will now be added to a larger base.

Long-term trends in the world zinc market show a positive relation with trends in per capita income. Numerous sources, including the United Nations, indicate that annual growth of per capita output of about 2% can be considered as normal for the developed countries over the long term. The 2% rate represents a benchmark against which to assess progress in the developing countries, which will grow even faster as they catch up. Indeed, developing countries, making up more than 50% of the world's population, grew at an annual rate of more than 2% per capita over the period 1971–1995; among these, developing countries, constituting nearly 30% of the world's population, grew by more than 3% a year in per capita terms.[29]

With that scenario, over the next 50 years, growth in zinc production is estimated to average 1.14% annually, compared to the 2.9% growth rate between 1950 and 2000. Growth in the 3% range is anticipated in the next few years, but it is anticipated to become much slower as the planning horizon is approached. The overriding concern and justification for anticipating a reduction in the growth rate is that most sources of world population projections express a deep seated concern for long-term sustainability of historic rates and allude to steady state goals and strategies. Indications from available data are that zinc production grows at about half the rate of growth of the world economy. There seems to be somewhat of a consensus

[29] 1997 Report on the World Social Situation, United Nations publication swt/ESA/252, accessible at http://www.un.org/esa/socdev/rwss97c0.htm.

among international planners that growth of the world economy will be maintained and probably accelerate even under steady state population trends.

**Table 13. Decade Trends: World Zinc Price, Production, and Economic Growth**

| | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2050 Projection |
|---|---|---|---|---|---|---|---|
| Zinc Produced in kmt[30] | 1,970 | 2,790 | 4,830 | 6,050 | 7,180 | 8,230 | 14,490[31] |
| Value per lb (98 prices) | $0.94 | $0.71 | $0.64 | $0.74 | $0.93 | $0.51 | $0.74[32]–$0.53[33] |
| Zinc Growth Rate | 2.97% | 3.57% | 4.98% | 1.73% | 1.73% | 1.37% | 1.14%–1.95%[34] |
| Population in Millions | 2,555.1 | 3,039.3 | 3,707.6 | 4,456.7 | 5,283.8 | 6,080.1 | 9,104[35] |
| Population growth Rate | 1.47% | 1.33 | 2.07% | 1.70% | 1.56% | 1.26% | 0.55% |
| World Economic Growth Rate[36] | No uniform database | No uniform database | No uniform database | No uniform database | 3.2% | 2.5% | 2.5%[37] |

**Supply Curve**. The World Mine Cost Data Exchange[38] mine cost model, used in this report, is based on U.S. Bureau of Mines Cost Estimating System or CES,[39] but also uses estimates of specific consumption of supplies such as fuel, power, explosives, grinding media, and reagents and labor requirements, plus adjustment factors for materials consumption and labor productivity. This allows combining the features of statistically-derived models such as CES with the Bill of Goods approach, which specifies actual costs and usage of production inputs. The end result is a more accurate cost estimate that can be verified against known or assumed usage rates of consumables and labor.

The cost estimating system can be customized to suit the user's particular needs and to fine tune cost estimates according to the availability of engineering and other operating data. Equations are provided for administrative, environmental, exploration, infrastructure, and long-distance transportation costs, in addition to surface and underground mining costs.

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[30] From a data set provided by Jozef Plachy, USGS Zinc Commodity Specialist, jplachy@usgs.gov and Carl A DiFrancesco, Minerals and Materials Analysis Section, USGS, difrance@usgs.gov.

[31] Derived from adding the historical 50-year growth to the year 2000 base.

[32] Historic average annual price at 1998 price levels.

[33] Near term expectation of $.53 is based on AME Mineral Economics as described in Draft Resource Transportation Analysis, Phase 1-Program Definition, prepared for Alaska Department of Transportation and Public Facilities, April 2001 by Ch2M Hill and Associates.

[34] 1.14% is the compound rate necessary to provide the increase between year 2000 and 2050. A growth rate based on per capita income would be 1.95%.

[35] U.S. Bureau of the Census, International Data Base http://www.census.gov/ipc/www/worldpop.html.

[36] Data for 1980–2000 from World Development Report 2000/2001: Attacking Poverty, August 2000 by Oxford University Press, World Bank ISBN: 0-19-521129-4 SKU: 61129.

[37] Estimated.

[38] World Mine Cost Data Exchange available at http://minecost.com/ or from World Mine Cost Data Exchange Inc, 3511 Silverside Road, Suite 105, Wilmington, DE 98810 U.S., Phone 212 903 4144 Fax 212 573 8362. www.minecost.com is a co-operative website using shared information from mining analysts employed by mining companies, stockbrokers, investment banks, commercial banks and government agencies.

[39] The first edition of the USBM costing system was prepared by STRAAM Engineers Inc. in 1975 as a USBM report Capital and Operating Cost Estimating Handbook, Mining and Beneficiation of Metallic and Nonmetallic Minerals Except Fossil Fuels in the United States and Canada. The report was published in 1977 as USBM OFR 10-78 and revised in 1978 and 1979. This report was often referred to as the STRAAM handbook. In 1987 the USBM revised the handbook and published it in two volumes as IC 9142 and 9143, BUREAU of Mines Cost Estimating System Handbook, usually referred to as CES. The revision was done by engineers and scientists at USBM Field Operations Centers in Denver and Spokane. Consulting contributors to CES were Pinnock, Allen & Holt.

Embedded cost models are also included for a wide variety of mineral processing plants as part of the system.

Applications of CES include: cost estimates of mineral deposits proposed for development, exploration targets, comparison of several mining and mineral processing scenarios, comparison of costs at various production capacities, regional studies of mineral deposits, and cost estimates of existing operations for comparison purposes.

The cost equations in CES are based on cost estimates for a variety of capacities, with current technology applicable to each section. Capital and operating costs are usually expressed in three equations: labor, supply, and equipment. The equations include the following categories:

- Labor: production labor, maintenance, construction, equipment installation
- Supply: steel items, steel pipe, lumber, explosives, construction materials (includes cement and gravel), industrial materials (includes plastic and ventilation pipe, electrical wiring, insulation, etc.), reagents, electricity
- Equipment: capital purchase, repair parts, fuel, lube, tires

For each category, a range of applicability is stated for the independent variable, usually daily production in metric tons. Using the cost equations for daily production outside this range could produce inaccurate results. In most cases, the range will cover any likely values that would occur in most mineral operations. Other units include face area in square meters for drifts, shafts, and other underground openings, width of road for access road sections, and amount of material in starter dam for tailings dam construction.

Bill of Goods models[40] are based on direct estimates of the use of each item of fuel, supplies, and other consumables. While in principle this approach produces better results, the detailed data is simply not available in most cases because the information is invariably regarded as commercially sensitive. Bill of Goods cost estimates, therefore, come from data provided by equipment manufacturers. The cost estimator applies typical consumables usage rates to the equipment believed (or assumed) to be in use at the operation. The estimates are then adjusted to reflect actual working conditions at the operation. In practice, this approach requires an immense amount of detail and is generally limited to the preparation of pre-feasibility studies or better, by insiders. For outsiders with limited access to the necessary data, the fallback position is to use some form of system modeling that plugs in valid assumptions or equations to fill the gaps. The World Mine Cost Data Exchange approach combines the statistical approach in CES with the Bill of Goods approach used by professional cost estimators.

Mine operating cost estimates and comparative rankings are used by analysts to assess the financial performance of mining companies. Mining companies themselves use mine cost models to compare their own performance against competitors and to better understand the economics of the industry. Mine cost data is also used to draw production cost curves showing industry competitive rankings in snapshot form.

[40] One organization that blends systems modeling with the bill of goods approach is Aventurine Mine Cost Engineering's Sherpa suite of computer programs.

The model used in this report has a focus of cash operating costs (direct mining expense + smelting + refining + transport costs + byproduct credits + royalties + production taxes + other = cash operating costs). The model uses offsite shipment, treatment, and refining charges in order to link the cost of production to refined metal; it uses published custom treatment charges based on standard treatment and refining contract terms, where relevant, for all mines, unless disclosed by the mine operator. This has the virtue of allowing mines to be compared on the basis of their own performance rather than on the efficiency or otherwise of the downstream smelter. The model was applied to a 81% sample of all zinc mines operating in 2003, including Red Dog. The supply curve allows Red Dog to be compared, using the same metric for all mines in the sample. The result illustrated that the operating cost of Red Dog at $0.305 per lb of finished zinc places it in the lower 54% of all zinc concentrate produced in 2003.

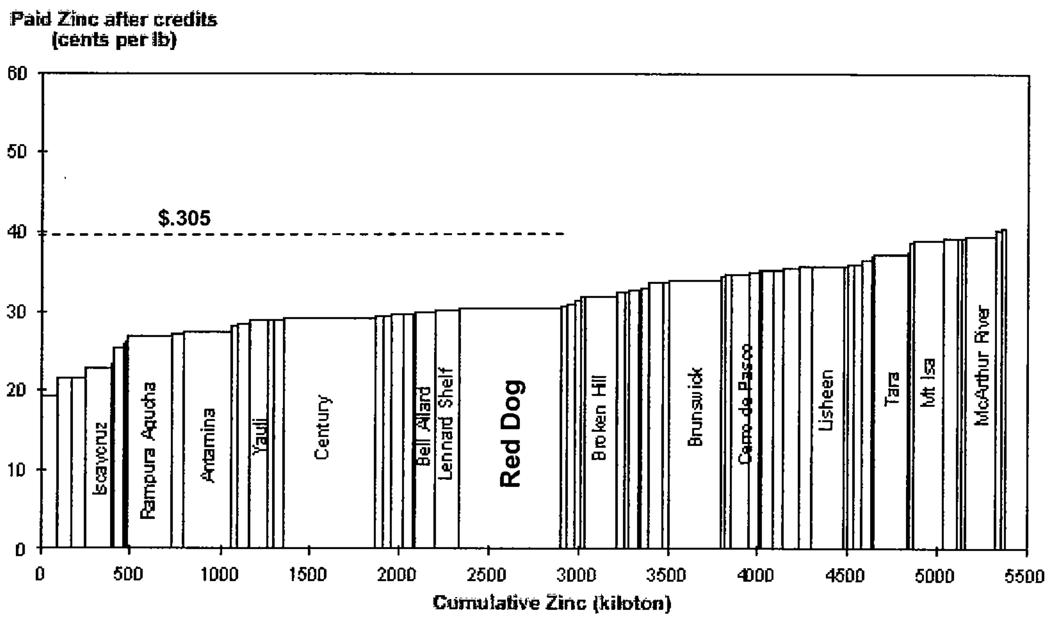


Figure 2. Zinc Cash Operating Costs 2003

In 2003 the model indicated that there were 2,476,600 tons produced by known western world mines having costs higher than Red Dog. It is concluded that at a modeled operating cost of under $.305 per lb, Red Dog can maintain production at the most severe adverse market conditions anticipated. It is unheard of that zinc prices have been maintained below $.305 per lb, and available price projections place the near term price (5–10 years) estimates at $.53 per lb and somewhat higher over the long-term future. The price projections are based on attempts to estimate the supply adjustments in terms of new mines and smelters that will be necessary to meet projections of growing demand. The general consensus is that zinc demand will grow at the rate of per capita income, and zinc supply will expand at increasingly higher cost of yet un-mined reserves. Against this background, Red Dog will continue to gain an economic advantage in the market because of its rich resources and because of the predicted entry of higher cost producers over the long-term. An added factor is that Red Dog has demonstrated a reduction in production cost from $.45 in 1991 to $.305 in 2003, indicating it can be anticipated to be a viable, competitive producer.

**Concentrate Commodity Projection.** Mining at Red Dog could began to extend into marginally lower quality ore reserves around 2011, if the rich reserves now being mined become fully used at present day mining rates. The new material will require more ore to be processed if the concentrate production goal[41] of 1,544,000 swt per year is to be maintained; however, maintenance of a fixed target level of output is not necessarily the only possible future. Whatever is selected as the appropriate level of output will be the result of a complex and continual analysis, bringing numerous variables into consideration. The analysis would be oversimplified, if one were to merely state that the deterioration in ore quality and other related changes will have the general tendency to drive up the cost per ton shipped, because there are numerous other changes taking place that affect the operating efficiency of the mine and the cost per unit of output regardless of the ore quality being mined. In the interest of maximizing the net income at the mine, there are also many strategies to be considered.

After 2011 when lower quality reserves are being mined, it is conceivable that maintenance of concentrate production at 1,544,000 swt could require new capital investment or other changes to adapt the mining and milling operation. Ore quality is anticipated to drop from 19.2% to about 16.9%, and indications are, if nothing is done, then concentrate shipments will drop from 1,544,000 swt to 1,352,000 swt while income suffers a proportionate decline. If zinc prices are at or below production cost, there is no economic incentive for the company to make up for the decline in concentrate shipments. However, even if the low prices of year 2002 were to return and persist, mine concentrate shipments could still be profitably maintained near 1,544,000 swt annually.

According to company policy, the Teck Cominco Alaska performance goal has been stated as seeking a minimum rate of return to capital of 10%, at a zinc price of $.45 per lb.[42] The Company annual report on the year 2000 indicated a return to assets for Red Dog Mine at around 11% during a year when the average zinc price was reported at $.51.[43] After year 2000 a mill optimization project boosted efficiency of the overall operation, and the company now anticipates an average return of about 24%, when production is at the maximum output level after 2003, while operating in the main pit. With a shift to Aqqaluk around 2011, the average return will stay in the +20% range after consideration of the depreciated capital base. Therefore, even with a decline in ore content looming around 2011, there is no pressure to increase output to maintain the company stated 10% return performance objective.[44]

Nevertheless, in the interest of maximizing net present value, the inevitable decline in ore content would appear to invite consideration of several courses of action, including the following options:

<u>CASE 1</u>. Do nothing and allow the amount of concentrate produced to decline to 1,352,000 swt, consistent with the decline in ore content. This would lead to a decline in gross income, net income, cash flow, and return on the investment; however, the overall rate of return

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[41] As a production goal, the estimate may differ from tons shipped in any year. The production goal is a theoretical and reasonable physical capacity of the mine and Portsite combined. The production goal does not account for interruptions due to extreme events which can have the effect of reducing tons shipped to an amount less than the production goal.

[42] *Cominco Annual Report For The Year 2000*, available at http://www.teckcominco.com/invrel/reports/clt-00-ar.pdf.

[43] Annual Report, pages 41 and 43, for a net earnings of $118,000,000 and Capital Assets of $1,038,000,000.

[44] Personal communication, Teck Cominco Alaska.

would be maintained well above the company stated performance objective. Since the Portsite system has a design capacity of 1,544,000 swt, there would be some unused shipping capacity.

CASE 2. Make adjustments necessary to continue concentrate shipping at 1,544,000 swt. This would allow gross income to be maintained at pre–2011 levels while resulting in the possibility of a decline in net income as a consequence of production bottlenecks in the way of higher extraction and processing. Portsite shipping capacity would be more fully employed.

CASE 3. Produce concentrate in excess of 1,544,000 swt, in search of bettering the mine economics. A hypothetical increase in production to 1,729,000 swt would shorten the mine life by about 10%, and most likely lead to productivity losses at the mine and mill operation.

**Production Comparison**. The following discussion compares CASE 1, 2, and 3 against present day production (BASE CASE) by applying the mine cost model to estimate net cash flow possibilities. Tables 14–17 show the results of the net cash flow comparison at the different zinc prices, given a variation in output levels and related assumptions about mine productivity.

Based on present day knowledge, shipments will max out at near 1,544,000 swt in most years because that is consistent with maximizing net cash flow and the system "design capacity" as it presently exists. At that level of concentrate production, activity at the mine is balanced with activity at the concentrator, the haul system, the concentrate storage buildings (CSB), and the barge loader.

Around 2011, there is a potential drop in net income. This potential drop in net income is not easily offset by marketing more concentrate, without some incremental capital improvements or increased operating costs. The production system constraints are hurdles to expansion of shipping, at a time when more concentrate will need to be shipped just to maintain a steady state of net income, if that is what the company elects to do. In the model, system limitations are expressed as inputs in the form of reduced production efficiency.

All of the alternative channel/trestle improvement plans will present the opportunity to ship more tons, and thus generating added income to cover some of the increased cost. However, in the event that the company does not elect to increase concentrate shipments, the proposed alternative navigation improvements will still help the Red Dog Mine maintain a stable rate of return by alleviating constraints, minimizing delays, reducing costs associated with the lightering system, and allowing for reduced fuel costs through the economies of delivery by deep draft tanker instead of shallow draft barge. In addition the modifications also introduce the potential for a higher port throughput after 2011.

The discussion in this report reviews a range of commodity projections, as reasonable upper and lower bounds of the most likely future, and selects a preferred level of concentrate shipments, based on the quantity necessary to maximize net cash flow with minimal added risk exposure, while supporting mining activity for at least 40 years.

The company makes investment decisions with zinc prices set at $.45 lb, which is somewhat lower than long-term average market prices but is a preferred choice, because it builds a certain measure of safety into investment decisions, which commit large amounts of capital for long periods of time. This report which addresses NED opportunities recognizes price possibilities in addition to a fixed price at $.45 lb.

Analysis of world supply and demand for zinc puts forward strong and compelling arguments for a price rebound as many operating mines run out of ore in the next few years and as the economy begins to recover from a world wide malaise. There are many credible professional sources who list reasons to expect price recovery to the +$.50 range in the 2003–2010 timeframe including:

- Standard Bank of London predicting $.51 at the beginning of the period
- Brook Hunt predicting $.55 before the end of the period
- CHR predicting $.54 at the beginning of the period

Zinc prices and expansion costs are both important to the economics of mine expansion. For example, in the case of Red Dog, if prices were to stabilize near or above $.53, it begins to appear economically attractive to increase the ore excavation rate to make up for the decrease in concentrate production, caused by the decline in ore quality, even though hypothetical productivity losses lead to an increase in average cost. At prices marginally below $.53, expansion beyond present capacity is not wise unless productivity losses are very small, in which case, expansion could be profitable all the way down to zinc at $.45 lb and lower.

More details regarding application of the mine cost model are presented in the Economics Appendix, Section 6.0, dealing with induced tonnage; within this section of the Appendix, dealing with the commodity projection, only the results of the cost model are shown. The following tables demonstrate the importance of considering variations in expected zinc prices and the potential for productivity losses (substitute for the cost of capacity expansion) when exploring positions on future mine production.

The bolded numbers (tables 15, 16) indicates the highest net cash flow options under the table assumptions. The "a" cases are based on productivity adjustments being made for all these cases. There is a near balance of options at zinc price of $.53, differing from high to low by 2%. Model inputs in the form of adjustments to productivity factors has the affect of increasing production cost for the two higher post–2011 output levels: CASE 2a and CASE 3a. Model productivity factors were adjusted inversely to increased mining activity as measured by changes in mill throughput. Productivity factors affected were: Mine Labor Productivity, Mill Labor Productivity, Fuel Use, Electricity Use, Materials Use, Drilling Conditions, Ground Conditions, and the Ore Work Index.

When adjustments were applied only to CASE 3, CASE 2 became the net cash flow choice at all zinc price levels. This is shown in the following table. The assumption, driving this table, is that normal annual capacity expansion and system updates will by 2011 accommodate increased mining and milling necessary to ship 1,544,000 swt of concentrate.

### Table 14. Production Characteristics With Changes In Ore Quality And Hypothetical Production Options

| | Base | Case 1 | Case 2 | Case 3 |
|---|---|---|---|---|
| | 2004 Present Design Capacity and Production Target | 2011 Quality Change | 2011 Quality Change Adjust Mining to Maintain 1,544,000 swt | 2011 Quality Change Adjust Mining To Exceed 1,544,000 swt |
| Concentrate Production (swt) | 1,544,000 | 1,352,000 | 1,544,000 | 1,729,000 |
| Open Pit Ore Mined (mt) | 4,085,000 | 4,018,000 | 4,608,000 | 5,044,000 |
| Open Pit Waste Mined (mt) | 4,018,000 | 4,018,000 | 5,040,000 | 5,044,000 |
| Mill Grades | | | | |
| Pb | 5.58% | 4.10% | 4.10% | 4.10% |
| Zn (gpt) | 19.20% | 16.60% | 16.60% | 16.60% |
| Ag (gpt) | 90.00 | 75.00 | 75.00 | 75.00 |
| Mill Recoveries | | | | |
| Pb (%) | 61.0% | 74.2% | 74.4% | 74.6% |
| Zn (%) | 81.9% | 83.6% | 83.6% | 83.0% |
| Ag (%) | 66.6% | 70.2% | 70.2% | 69.9% |
| Metal Production | | | | |
| Pb (mt) | 1,390 | 1,240 | 1,430 | 1,610 |
| Zn (mt) | 642.0 | 565.6 | 650.0 | 726.0 |
| Ag | 245.0 | 214.6 | 250.0 | 280.0 |
| Concentrate Production | | | | |
| Lead Concentrate (mt) | 235,600 | 210,200 | 242,400 | 272,900 |
| Zinc Concentrate (mt) | 1,156,800 | 1,019,100 | 1,171,200 | 1,329,700 |
| Total (mt) | 1,392,300 | 1,229,300 | 1,413,600 | 1,602,600 |
| Total (swt) | 1,531,500 | 1,352,200 | 1,554,900 | 1,762,900 |
| Comparable Nominal Production Level (swt) | 1,544,000 | 1,352,000 | 1,544,000 | 1,729,000 |

### Table 15. Net Cash Flow Variations With Productivity Adjustments Made For Mine And Mill Operations

| | BASE 2004 Baseline Production Target 1,544,000 st | CASE 1a 2011 Quality Change No Adjustment Produces 1,352,000 st | CASE 2a 2011 Quality Change Adjust Mine to Maintain 1,544,000 st and Adjust Mine/Mill Productivity | CASE 3a 2011 Quality Change Adjust Mine to Produce 1,729,000 st and Adjust Mine/Mill Productivity |
|---|---|---|---|---|
| Operating Net Cash Flow $Millions Annually | | | | |
| @ $0.45/lb | 177.7 | 142.7 | 125.1 | 118.5 |
| @ 0.47/lb | 201.2 | 163.4 | 148.8 | 145.0 |
| @ 0.50/lb | 236.5 | 194.5 | 184.5 | 184.9 |
| @ 0.53/lb | 271.8 | 225.5 | 220.1 | 224.8 |
| @ 0.56/lb | 307.0 | 256.6 | 255.8 | 264.7 |
| Cost after Credits | | | | |
| Finished Zinc (c/lb) | 30.5 | 32.8 | 34.7 | 36.3 |

### Table 16. Net Cash Flow Variations Productivity Adjustments For Mine And Mill Operations For Case 3 Only

| | BASE 2004 Baseline Production Target 1,544,000 st | CASE 1b 2011 Quality Change No Adjustment Produces 1,352,000 st | CASE 2b 2011 Quality Change Mine Maintains 1,544,000 st | CASE 3b 2011 Quality Change Mine Produces 1,729,000 st |
|---|---|---|---|---|
| Operating Net Cash Flow $Millions Annually | | | | |
| @ $0.45/lb | 177.7 | 142.7 | 156.7 | 118.5 |
| @ 0.47/lb | 201.2 | 163.4 | 180.5 | 145.0 |
| @ 0.50/lb | 236.5 | 194.5 | 216.2 | 184.9 |
| @ 0.53/lb | 271.8 | 225.5 | 251.9 | 224.8 |
| @ 0.56/lb | 307.0 | 256.6 | 287.5 | 264.7 |
| Cost after Credits | | | | |
| Finished Zinc (c/lb) | 30.5 | 32.8 | 32.3 | 36.5 |

An important consideration is that the CASE 2 concentrate level can be accommodated without expansion of the concentrate storage buildings (CSB). At any higher level of output, the CSB facilities would have to be expanded, and this type of major construction is not in the history of the mine's continual expansion and modification. Limitations of the CSB, therefore, tend to limit concentrate shipping to the CASE 2b choice of 1,544,000 swt. Also, beyond a throughput of 1,544,000 swt it is assumed that other system restrictions will introduce a decline of productivity with a direct relation between increased throughput and decreased productivity. With this assumption, a 30% increase in throughput beyond 1,544,000 swt would result in a 30% decrease in productivity and in materials usage efficiency.

**Table 17. Net Cash Flow Variations No Productivity Adjustments For Mine And Mill Operations**

| | BASE 2004 Baseline 1,544,000 st | CASE 1c 2011 Quality Change 1,352,000st | CASE 2c 2011 Quality Change 1,544,000st | CASE 3c 2011 Quality Change 1,729,000st |
|---|---|---|---|---|
| Operating Net Cash Flow $Millions Annually | | | | |
| @ $0.45/lb | 177.7 | 142.7 | 156.7 | 183.1 |
| @ 0.47/lb | 201.2 | 163.4 | 180.5 | 201.7 |
| @ 0.50/lb | 236.5 | 194.5 | 216.2 | 249.5 |
| @ 0.53/lb | 271.8 | 225.5 | 251.9 | 289.4 |
| @ 0.56/lb | 307.0 | 256.6 | 287.5 | 329.3 |
| Cost after Credits | | | | |
| Finished Zinc (c/lb) | 30.5 | 32.8 | 32.3 | 31.7 |

By 2011 enough capacity could possibly be added by customary management strategy to deal with some of the increased throughput but probably not adequately to make up for quality losses, without a special program and not without significant cost. It is unlikely that CASE 3 net cash flow shown above could be reached at zero incremental capital cost, and this would render the above outcome unreachable.

Table 17, mine, mill, and other expansion cost are hidden as sunk cost, thus further overstating CASE 3c. Expansion cost is assumed to be recoverable, but this is unproven. Of paramount importance is that CASE 3c expansion would also need to address extreme limitations of the CSB and haul system, either one of which would very likely rule out the CASE 3c expansion, even under the best sets of accompanying assumptions. CASE 3 appears to show indications of the highest net cash flow, but one must be cautious when these unmeasured economic, policy, and environmental aspects of the throughput level are considered; CASE 3c is a very remote possibility.

Although not accounted for in the above table, efficiency of the operation will be degraded by forcing a higher throughput. Modification costs to remove bottlenecks have not been estimated. Inclusion of these costs could easily move the net cash flow advantage to favor maintaining concentrate output at 1,544,000 swt, CASE 2b. This observation is based on prior expansion cost of $105 million in 1999, which increased mill capacity by about 40%, and another expansion project completed in 2001, which cost about $200 million and increased the effectiveness of the treatment systems.

Expansion to exceed 1,544,000 swt can be accommodated by the proposed port modifications; however, certain upstream mine modifications, such as expansion of the CSB, floatation system, generating capacity, and possibly the milling operation, would be costly and are not being planned.

A long-term production goal of 1,729,000 swt of concentrate could provide a strong net cash flow among the choices evaluated only if one makes extreme assumptions about capacity expansion. It indicates possible increased return and low production cost only if one is able to support an assumption of zero incremental expansion cost, which realistically cannot be done. Therefore, this projected hypothetical production goal of 1,729,000 swt is considered to be a unlikely future, far from the most probable, because the risks and costs are not apparent in the net cash flow calculation. It is also discouraged, if not ruled out, by the fact the mine operator, TCAK, and the resource owner, NANA, operate under an agreement that provides economic stability to the region and employment for NANA shareholders over a 40-year period; a production goal of 1,729,000 swt could violate this agreement.

Settling on a most probable future projection requires making judgments about mine operations where data is soft or not yet developed. From a rational point of view the ability to further expand the mine and identify a "most likely production level" is a function of the economics of the incremental investment; however, there are many unknowns. Among them is the uncertainty of going underground for new resources, and this is considered to be a major concern not fully included in the economics of any expansion plan. At this point the unknown practical limits of an underground operation might introduce new limits to mine output or unforeseen variable costs regardless of market prices or incremental investment requirements. A most probable future production goal would have to take into account the circumstances surrounding the underground operation, which are unknown at the present time but which would discourage contemplating aggressive expansion while moving into new resources. Aside from mine and mill capacity constraints, there is also the matter of limits imposed by CSB size and haul rates.

In this report, the output goal for the coming decade is anticipated to be maintained at 1,544,000 swt even though a return to higher prices is anticipated well before year 2011. In the without-project condition, the production goal will remain at 1,544,000 swt, even beyond year 2011, with a possible decrease in net income as a result of a decrease in ore quality. With lower ore quality, it will cost more to produce 1,544,000 swt of concentrate.

In the with-project condition, the output goal could increase around 2011, merely because downstream of the CSB, system shipping constraints are not quite so limiting at that point in time. Weighing against this, however, is the potentially huge investment necessary to de-bottleneck upstream facilities. A slight increase in the shipping target could have economic merit; however, it must also be stated that Red Dog could comfortably exceed investment objectives even without any expansion in the amount of concentrate shipped. One adverse impact of expansion towards 1,729,000 swt is that it would result in accelerated depletion, which could be viewed as an unacceptable and unnecessary consequence. Therefore, the prospects for expansion toward 1,729,000 swt could rest heavily on acceptance of an assumption that there will be future resource discoveries. An output level of 1,729,000 swt is, at best, considered to be only remotely possible and very unlikely as a reasonably probable upper bound. The lower bound is 1,352,000 swt; the system design capacity of 1,544,000 swt is the most likely long-term projection.

**Reserves and Resources**. In year 2000, close to 90% of the exploration program of Teck Cominco Alaska was spent looking for zinc. Teck Cominco Alaska is focused on high grade, large tonnage deposits likely to meet the corporate target of generating at least a 10% return on capital at a zinc price of $.45 lb. The Red Dog area is the most significant zinc district in the world, with many indications that there is a potential for more discoveries. Teck Cominco Alaska holds approximately 370,500 acres of mineral rights in the region. Reflecting the company's confidence in making more discoveries, $12 million of the company's year 2000 exploration expenditure of $33 million was spent in the Red Dog area.

During 2000, delineation drilling outlined the limits of the Anarraaq deposit, which was discovered in 1999. That deposit is estimated to contain 17.2 million tons of resources, grading 15.8% zinc, 4.8% lead, and 71 grams of silver per ton. Also in 2000, yet another area of mineralization was discovered near Anarraaq, and gravity surveys and borehole geophysics identified several other new target areas. These latest discoveries are not included in the resource inventories estimated elsewhere in this report. The classification system used by Teck Cominco Alaska is as follows:

Proven Reserves. Those ore reserves being developed at a mine for which confidence exists that economic extraction can be justified.

Probable Reserves. Where there is a sufficient level of confidence and information known about the deposit or a portion of it to justify major expenditure.

Resources. A sufficient deposit or concentration of minerals with sufficient sampling and geological understanding to outline a deposit of potential economic merit and classed as measured, indicated, or inferred.

Measured Resource. The portion of a resource with a high level of confidence in the geology to support an economic evaluation.

Indicated Resource. When there is sufficient information about the geology, continuity, grade, and tonnage to support an economic evaluation.

Inferred Resource. A projection of mineralization, computed on the basis of limited drilling, but reasonable understanding of the geology and the distribution and correlation of metal values.

**Resource Assessment.** The Red Dog Mine began operation in 1989, and first shipped ore concentrates in 1990 with zinc and lead production climbing steadily throughout the 1990s. In 2004 Red Dog is the world's most productive zinc mine with an estimated present "design capacity" adequate to ship 1,544,000 swt of concentrate. Actual capacity in any year will depend on a number of variables that can shut down shipping such as waves, wind and ice, limitations of installed equipment, product prices, and production goals.

The mine operator, TCAK, estimates its discovered reserves in the Red Dog area can support more than 40 years of production at the current rate. This estimate is supported by several other external information sources, which have reported on the estimated quantity and quality of additional nearby reserves. According to NANA, the owner of the resource, in a web page article accessed in 2004, there are now enough known resources in the immediate mine area to support 50-years of production.[45] According to the industry (International Zinc Association) in 2004, the world-class ore body currently has at least 40 years of reserves with good potential to discover additional ore.[46]

In addition, there are also reserves at the Su Lik deposit and Anarraaq deposits, located 12 miles and 6 miles from Red Dog, respectively. The mine uses the Alaska Industrial Development and Export Authority (AIDEA) owned Portsite for shipping and has a contract through June 30, 2040, with 5 optional 10-year extensions.

Four deposits are grouped together near the concentrator; the Main, Aqqaluk, and Qanaiyaq are at surface, and the Paalaaq lies at a depth of 180 to 425 m. The table below outlines the reported reserves and resources of the four nearby deposits as of the end of 2000.

[45] NANA statement accessed at http://www.nana.com/pdfs/NANA%20and%20Mining.pdf.

[46] *Zinc and Sustainable Development The Case of the Red Dog Mine*, Doug Horswill, Deirdre Riley and David, Parker Cominco Ltd, in Zincworld, 68 Avenue de Tervueren Box 4, B-1150 Brussels, Belgium, accessed at Http://www.iza.com.

**Table 18. Reserves And Resources (tons [000]) In The Four Deposits At The Red Dog Mine Site[47]**

| Identification | Quantity | | | |
|---|---|---|---|---|
| | Total | Zn% | Pb% | Ag g/tonne |
| Proven reserves (Main) | 41,900 | 19.2 | 5.2 | 100 |
| Probable reserves (Aqqaluk) | 56,100 | 16.6 | 4.1 | 76 |
| TOTAL RESERVES | 98,000 | 17.7 | 4.6 | 86 |
| Indicated resources (Qanaiyaq) | 9,600 | 17.8 | 5.5 | 117 |
| Indicated resources (Aqqaluk) | 3,400 | 9.8 | 3.7 | 78 |
| Inferred resources (Aqqaluk) | 6,800 | 6.5 | 3.6 | 59 |
| Inferred resources (Paalaaq) | 13,000 | 15.0 | 4.0 | 90 |
| TOTAL RESOURCES | 32,800 | 13.5 | 4.3 | 90 |
| TOTAL RESERVES and RESOURCES | 130,800 | 16.65 | 4.5 | 87 |

The Su-Lik deposit is located to the northwest and the Anarraaq to the north of the Main zone; the latter was discovered in 1999. The Red Dog zinc district, contained within the Delong Zinc Belt, is the largest ever discovered in the world, and the above table represents about 24% of the world's known zinc reserves. To date, mining is confined to the Main zone with many identified exploration targets waiting to be examined. The Su-Lik deposit, which has claims owned by Teck Cominco Alaska and GCO of Houston, TX., is estimated to contain 34 million tons, grading 8% Zn, 2% Pb, and 30 g/tonne Ag. Anarraaq contains an inferred resource of 17.2 million tons, grading 15.8% Zn, 4.8% Pb, and 71 g/tonne Ag. Most of Anarraaq lies more than 600 m below the surface. Beyond the estimates in the above table are the Su-Lik and Anarraaq deposits, which when added to the table, makes for a total of 182,000,000 tons.

In the earliest stages of exploration, specific sites are not drilled, and information is often so sketchy as to not even qualify for any of the above resource categories. An example would be the Anarraaq deposit, which was listed as inferred in the company 2000 Annual Report but not even classified in the 1999 Annual Report. A supportive positive assessment in the 1999 Annual report states, "The probability for discovering new high grade resources in the Red Dog District is high…"; another one states, "The mine marked its 11th anniversary in 2000 and still has a long life ahead of it, with strong prospects of adding to reserves through exploration." Another statement in the 2000 Annual Report emphasizes prospects for development of new deposits saying, "A major advance in metallurgical technology by Cominco research and others will allow development of zinc oxide deposits that were not previously economic. This will open future opportunities as Cominco's exploration focuses on areas likely to host zinc oxide deposits."

There are some differences among various resource assessments, and the estimates are also continually changing, but they all appear to indicate that reserves are more than adequate to assure a mine life of 40 or more years. For example, the company annual report for 2000 estimated total area resources and reserves at 148 million tons, grading an average of 16.6%

[47] *Red Dog Mine Cominco's Alaskan Triumph*, Jane Werniuk, appearing in The Canadian Mining Journal April 2000 (Table total calculated for this report).

zinc, 4.5% lead, and 85 grams of silver per ton. This is about 5% greater than estimates made a year earlier because of new information typical of mineral exploration efforts.

Given that the company has an intense exploration effort and that it is effective as a means of discovery and verification, the company estimate would appear to be a safe low range estimate. This conservative low range estimate offsets some of the risk inherent in mining ventures; in contrast, the Canadian Mining Journal estimates a total of 191 million tons, without eliminating economically marginal resources and 182 million tons with a cutoff at 6%. The nature of both sources is that they are continually changing as new information is discovered. A reasonable estimate of the reserves and resources near Red Dog would range from the Cominco (2000) estimate of 148 million tons to the 182 million tons of potentially economically viable ore bodies alluded to in the Canadian Mining Journal.

An argument could be made that both estimates are conservative and that up to another 40 million tons could be considered as potential additions, for a total of up to 231 million tons, if one includes The Alaska Miners Association Railroad Committee estimate of other Delong Mountain reserves in a publication titled *Future Mineral Freight Estimates-Interior Alaska*. The publication classifies "Class 1" reserves as those having a greater than 25% chance of being developed inside of a decade. Identified as having Class 1 potential, are prospects at Drenchwater, Story Creek, and Kivliktort Mountain. Taken together these deposits are reported to have the potential for production of concentrate volumes of 500,000 to 800,000 swt per year, for 20–50 years. The 50-year economic analysis of the various proposed navigation improvements in this feasibility report is not dependent on exploitation of reserves outside of the current mine.

It is concluded that prospects of new discoveries are excellent and over a wider area, and would exceed the resources and reserves categorized publicly by TCAK to date. It is anticipated that the areas of zinc resources and reserves, already estimated as of year 2001 by various sources at 130.8 million tons, 148 million tons, 182 million tons, 191 million tons, and 231 million tons, would support average annual concentrate shipments of 1,544,000 swt annually for 36 years, 41 years, 50 years, 52 years and 63 years, respectively. This assumes the ore reduction factor at the concentrator (about .42, based on Mine Cost Model simulations of operations in 2004 with anticipation of 2005, will remain reasonably constant). This report has elected to use a rounded average of the three lowest estimates indicating 42 years of mine activity remaining after 2000. In the with-project condition, the benefits become effective in 2011 creating a benefit stream from 31 years of concentrate shipments.

**General Cargo**. General cargo shipments are a function of the scale of operation at Red Dog. A history of shipments and production since 1989 has allowed a reliable relation between mine output and general cargo shipments to be constructed. At an output level of 1,544,000 swt of concentrate annually, the general cargo requirements are as follows:

| General Supplies | 27,000 tons |
|---|---|
| Containerized | 1,000 tons |
| Containerized grinding media | 7,000 tons |
| TOTAL | 35,000 tons |

Given that there is a reliable relationship between st of general cargo and tons of material mined, an increase of 12% in material mined would increase general cargo requirements to about 39,000 swt annually. All of the general cargo is delivered by barge requiring about 6–8 loaded barges per year.

**Red Dog Fuel Use.** Natural gas explorations are underway near Red Dog to test potential productivity of known shale gas fields. If high quality resources are verified, it may be possible to use onsite natural gas, at least, as a partial energy source for the mine. This possibility introduces a measure of uncertainty to the projection of petroleum products shipped to Red Dog. However, in the event natural gas fields are developed, there is the countervailing prospect of shipping natural gas as a commodity out of Portsite. None of the potential effects of natural gas development are included in the commodity projection of this report, due to the uncertain economic and environmental aspects of developing the resource.

Diesel fuel is barged to the port by Crowley marine in tanker barges of 5.25 million U.S. gallons capacity, and the barges call first at Kotzebue to offload about 1 million gallons each, and as a result, they reduce their draft to 17 ft, which allows them to call at Portsite. At Portsite each barge will offload about 4 million gallons directly to the Portsite tank farm.

A minor amount of the fuel is piped from the tank farm to the port generating station, and the balance is trucked to the mine for power generation and for consumption by mobile equipment. The self-unloading barges that shuttle concentrate from the conveyor to the ships anchored offshore arrive onsite each spring with their own self contained fuel storage and require no other fuel.

Given the current target production level of 1,544,000 swt of concentrate and the present port configuration, 22,357,000 gallons of fuel will be consumed each year, about 14.48 gallons per swt of concentrate,[48] or a total of 76,000 tons. This pattern will remain in effect as long as the production level is maintained at the existing ore grades. When ore grade changes about 2011, mining and milling will need to increase about 10%, if tonnage shipped is to remain at 1,544,000 swt. Additional mining and milling will contribute to an increase in fuel requirements, estimated to total 25,721,500 gallons or 88,132 st. At a potential but unlikely increase in concentrate shipping to 1,729,000 swt, fuel use at Red Dog could increase by 30% to an estimated 29,064,100 gallons or 98,800 st.

In the with-project condition the dedicated tug and barge fleet, which is not fueled at Portsite, will be replaced with two 4,000 HP tugs fueled at Portsite during the season. Tugs of this size carry 92,000 gallons of fuel, which is adequate to power them to and from Portsite. They will top off once during the season and represent a potential 101,400 gallon demand for Portsite fuel, based on 690 assist hours during the season. The trestle-channel project also includes generation efficiency, which results in a reduced fuel demand per kWh. Countering this savings is an addition of mechanical equipment related to the new conveyor and its loading activities, which increases electricity requirements. Overall the net result is to add a fuel requirement of 208,900 gallons over the without-project condition. Therefore, fuel

[48] Calculated from mine records of actual tonnage shipped in 2001 and actual fuel used. Fuel conversion applied a specific gravity of .81, 6.8 lb/gallon, and 294 gallons per ton. This represents a balance of gas oil and kerosene.

requirements for the mine in the with-project condition are 25,921,400 gallons (88,132 tons) at a production level of 1,544,000 swt annually.

**Fuel Use at Regional Communities**. With improvements to Portsite, under the with-project condition, fuel supply will be delivered by deep draft tankers instead of the higher cost barge fleet now in use. This tanker will account for 4 deep draft vessel calls per year. This increase in the with-project condition is because fuel, now bound for Kotzebue and surrounding villages from Puget Sound and the Kenai Peninsula, would be delivered to Portsite from Singapore, because there will be an economic savings to do so. Similarly, fuel needed by other villages in the region would also originate from Singapore and be delivered to Portsite by means of a deep draft tanker and then redistributed from Portsite to the villages by lighters.

For example, in a typical year approximately 4.5 million gallons of product (includes HF #1, DF #2, aviation fuels, and unleaded gasoline) comes into Kotzebue each year and is consumed locally. This entire product is wholesaled and retailed by Crowley Marine Services (Arctic Lighterage). An additional 1.5 million in #2 comes into Kotzebue to the local electric cooperative, and another 1.5 to 2.0 million gallons in product comes into Kotzebue, then is transferred by barge to seven outlying villages.

With the use of deep draft tankers, cheaper fuel expands the area that can be served from Portsite to a 600 mile round trip (300 mile radius) for a 200,000 gallon (680 ton) load, delivered by lighter at an average speed of 8 mph. For lighters of larger size, the area is expanded much further. At the lower limit with the least economical lighters, the increased radius includes Nome, so in the worst case, additional villages now served from Nome plus Nome itself could be served at less overall cost from Portsite, thus adding 10,000,000 gallons per year (32,000 tons) to the fuel delivered into and out of Portsite.

Other small villages in the area could be served by small lighters or direct from Portsite by larger barges, and there is also an excellent option for serving Nome directly from Portsite by use of an ocean going tug/barge combination drafting 17 ft, with a 12,000 dwst, capable of hauling up to 3,500,000 gallons per trip. The larger barge introduces additional economies and expands the service area south to include villages on the Yukon River and north to Barrow.

The prospective with-project delivery eventually involving 58,746,700 gallons (25,921,400 to the mine, 32,825,300 to villages) can be managed through the addition of about 2 million gallons of gasoline storage to the existing 15 million gallons of fuel oil storage at the Portsite facility and existing 2 million gallons of fuel oil storage at the Red Dog Mine.

The details involving examination of the prospects for increased fuel shipments are handled separately in this report, within the sections bearing the words, Fuel Delivery in the title. The reader should refer to those sections for details regarding destination, route, mode, origin, equipment, cost, quantities, etc.

**Table 19. Gallons Of With-Project Condition Fuel Delivery (Including Double Handling**)**

| VILLAGE | MODE | FUEL OIL | GAS | TOTAL | TONS |
|---|---|---|---|---|---|
| Kotzebue | Ocean Barge from port site | 5,200,000 | 800,000 | 6,000,000 | 20,400 |
| Kotzebue area Villages | Lighter from port site | 1,313,000 | 437,000 | 1,750,000 | 5,950 |
| 5 Kotzebue Swing Villages | Coastal Barge from port site | 4,500,000 | 1,927,000 | 6,427,000 | 21,850 |
| Nome | Ocean Barge from port site | 8,000,000 | 2,000,000 | 10,000,000 | 34,000 |
| Nome area Villages** | From Portsite to Nome then via Lighter from Nome** | 1,100,000 | 300,000 | 1,400,000 | 4,760** |
| Village Direct | Ocean Barge and Lighter from Portsite | 2,777,600 | 242,000 | 3,019,600 | 10,270 |
| 7 Yukon Swing Villages | From Portsite to Nome then via Lighter from Nome | 1,398,500 | 466,100 | 1,864,600 | 6,330 |
| Yukon Delta/Lower River | From Portsite to Nome then via Lighter from Nome | 2,829,100 | 935,000 | 3,764,100 | 12,800 |
| Red Dog Mine | Deep Draft Vessel from Singapore to port site | 25,921,400 | 0 | 25,921,400 | 88,130 |
| TOTAL including re-delivery | | 53,039,600 | 7,107,100 | 60,146,700 | 204,500 |
| TOTAL to PORTSITE | | 451,939,600 | 6,807,100 | 58,746,700 | 199,740 |

Note: Definitions for Swing Villages, Village Direct, Yukon Swing Villages, are found in section 7 of this appendix.

**Coal.** Against the plan to bring in fuel with deep draft tankers is the idea that a coal fired generating plant (near the mine mouth) has been proposed by the Arctic Slope Regional Corporation (ASRC), and if developed, it would transmit power to the Red Dog Mine. This 300 MW plant would consume about 1.4 million tons of coal annually with the end result of reducing the amount of diesel fuel brought into the mine.

Planning data indicates that, compared to other coal now on the world market, ASRC resources have a low sulfur content and high btu. Quality indications are that regional coal resources would be in wide demand, if available at competitive prices. Unfortunately there are no cost estimates available for mine development, coal extraction, power plant development, or transmission line construction; it is not possible to estimate how well the Alaska coal sources would be able to compete in the world market or how much coal fired electricity would cost by the time it was delivered at the Red Dog Mine.

Regarding world demand for coal, comparable to the quality of ASRC resources, there is no question of a potential market. However, there are major challenges particularly in that markets would need to be served using ocean bulk carriers, and the climate conditions of Alaska rule out year around seaports in the vicinity of the coal fields. Steady year around supply is essential to coal users. Even though Asian steam coal needs exceed 200 million tons annually, and the Asian market is very close to Alaska, any attempt to capture a share of the market would be handicapped by present day economics. In the long run there are numerous possibilities; however, in the near term time frame of this study, more data is required before coal can be introduced as a commodity for shipment through Portsite in a way that will affect project economics.

One estimate of potential domestic shipment by water has been made at 1 million tons.[49] One concept plan calls for barged coal to be shipped from Portsite to the Donlin Creek mining area, which is accessible from Portsite by using barges down the coast and thence up the Kuskokwim River. However, at the time of this writing, significant parts of the transportation link (coal fields to Portsite) are undeveloped, making this a long-term pursuit. The intended eventual end use would be as steam coal for a generating facility being planned as a power supply for future mining activity.

Modification of Portsite will introduce a deep-sea dock to the region. This will offer the possibility of introducing test shipments of coal into the world market using the new conveyor and ship loading system, providing a means is developed to deliver coal to Portsite. With concentrate shipments at 1,544,000 swt annually, there will be sufficient berth availability to make several coal shipments each year.

**Deep Draft Commodity Projection**. Concentrate shipments make up most of the present and future deep draft shipments. In the without-project condition, a number of factors combine to produce a practical limit on Portsite concentrate throughput capacity at near 1,544,000 swt annually. As the mine expands into ore bodies that are not as rich as the main supply, economic incentives will present themselves for development of increased ore extraction to maintain shipment targets.

One potential, although unlikely, increase in the shipping target could be expected around 2011, as economics might eventually favor an increase of about 185,000 swt annually, for a total of 1,729,000 swt, although it is considered to be a remote possibility. The chart below illustrates the general nature of the future expectation. The chart is not to scale and only illustrates potential future shipments providing port bottlenecks are improved. Essentially it depicts the "with-project condition."

The chart depicts some future commodity flows that are uncertain, regarding their rate of development and the time at which they might occur. However, given the rich mineral reserves and the rate at which the state and regional governments are moving to develop a regional transportation strategy and infrastructure, the projection may turn out to be a conservative view.

The projected shipment of coal, copper, and zinc shown above as "uncertain" does not enter into the economic evaluation of improvements to Portsite for several reasons:

- The resources cannot be extracted and moved to a shipping point without significant new transportation infrastructure now in the earliest stages of planning.
- Unknown environmental, social, economic, or political issues may arise that adversely impact the viability of extraction.
- There is a great deal of uncertainty in the strategy that will develop to take advantage of the resources, who the major parties will be, what legal, environmental, economic, and social constraints might apply.

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[49] Teresa Imm, Arctic Slope regional Corporation, in a February 2001 telephone interview with Bill Wong noted in *Northwest Alaska Resource Development Transportation Alternatives Study*, prepared for Alaska Industrial Development and Export Authority by CH$^2$M Hill and Sandwell Inc. in December of 1992.

- Shipping potential for new commodities at some distant point in time is not one of the reasons that present shipping problems at Portsite need to be corrected.

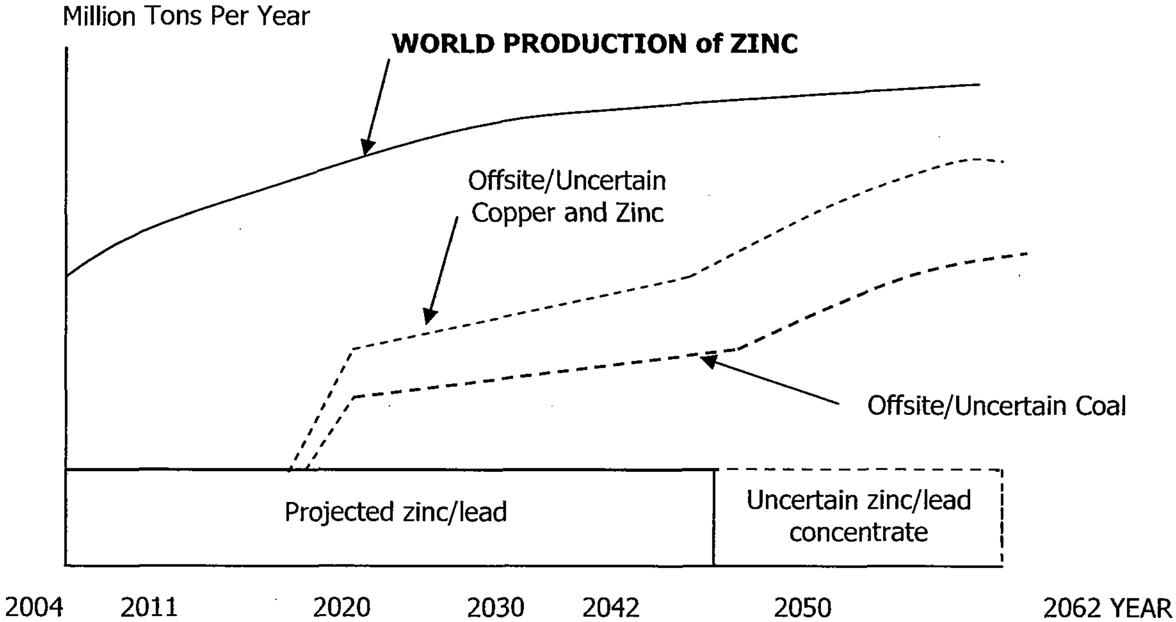


Figure 3. Potential Portsite Base Metal Shipments (Not to scale)

**Commodity Projection Summary**. The table below summarizes the foregoing discussion in terms of anticipated tons of cargo through Portsite. Coal, copper, some future zinc, and gas have been treated as unknown.

**Table 20. SWT (000) Projected Available for Shipping**

| WITHOUT PROJECT | | | WITH PROJECT | | | | |
|---|---|---|---|---|---|---|---|
| Year | barge in | target deep draft out | barge in | barge-lighter out | deep draft in | high deep draft out | most likely deep draft out |
| 2004 | 111.0[50] | 1,544.0 | - | - | - | - | - |
| 2011 | 115.0 | 1,544.0 | 39.0 | 111.6 | 199.7 | 1,729.0 | 1,544.0 |
| 2020 | 115.0 | 1,544.0 | 39.0 | 111.6 | 199.7 | 1,729.0 | 1,544.0 |
| 2030 | 115.0 | 1,544.0 | 39.0 | 111.6 | 199.7 | 1,729.0 | 1,544.0 |
| 2040 | 115.0 | 1,544.0 | 39.0 | 111.6 | 199.7 | 1,729.0 | 1,544.0 |
| 2050 | - | - | - | - | - | - | |
| 2060 | - | - | - | - | - | - | |

[50] Includes fuel to the Portsite tank farm.

# 4.0 FLEET PROJECTION

**Purpose**. This section of the feasibility report examines the type of deep draft vessels that have been in use at Portsite and makes a projection of trends in vessel use, based on the least cost means of servicing destinations. This is done while giving consideration to conventional marketing practices, destination port restrictions, and restrictions at Portsite. Restrictions at Portsite come into play only indirectly in the with-project condition because of the need to consider a spread of project depths to identify the NED scale.

The fleet is used as input to the shipping simulator; also, after the different sized vessels are reduced to a cost per ton, the information is used as a means of estimating the cost of moving commodities in both the with-project and without-project condition. It is therefore a fundamental input to the benefit evaluation.

**Methodology**. The analysis of the fleet is dependent on vessel schedules, loading patterns, and destinations established by actual operations from 1996 through 1999. This basic data excludes the first 6 years of the Red Dog Mine operation, during which time rapid expansion of the mine and shipping facilities established data sets that might be considered unrepresentative of the operation in later years merely because of the smaller scale of production. There has been some ongoing expansion of the throughput capacity of the storage buildings, concentrator, and other aspects of the operation; however the transportation policies and practices in 1996–1999 were essentially the same as they are today. The activities involved in the barge loading operation are unchanged, and the fleet of tugs and barges is the same as in 1996.

This section of the report deals only with the deep draft bulk carrier fleet, leaving the tug and barge operation to be analyzed separately. The 1996–1999 TCAK deep draft database was a prime data source for this analysis.[51] Related data generated for this study included distances from Portsite to the first call destination ports, depth, and other port constraints, which could limit the size of the vessel or the size of the load to be delivered. The database contained two vessel classes "Panamax" and "Handysize" size. These vessels are generally about 77,000 dwst, and 44,000 dwst, respectively, and at their maximum salt water draft, draw about 45 ft[52] and 37 ft. The two vessel classes make up 100% of the deep draft fleet in the without-project condition. Vessel operating cost was estimated using the Corps' latest information, available at the time of preparation of this report, which presented an official vessel cost database for use in Corps' reports in 2004. The Corps issues official guidance memos to its field offices, detailing the vessel cost information to be used in Corps reports.[53] The vessel cost data used in this report had not yet been published in an Economics Guidance Memorandum (EGM) at the time it was required as up-to-date input. For that reason there is little detail available to explain how the costs are derived and how they are reconciled with costs from other sources. Nevertheless the costs represent an official requirement where

[51] Unpublished primary data file supplied to the Corps by TCAK.

[52] Panamax class vessels can load deeper than the limits of the Panama Canal limit because they transit to European ports via the Suez. Panama Canal dimensions are therefore not a controlling factor for the fleet.

[53] Preliminary draft data in advance of *FY 2004 Planning Guidance Deep Draft Vessel Costs*, Economics Guidance Memorandum 02-6, Deep Draft Vessel Operating Costs, CECW-PD, http://www.usace.army.mil/inet/functions/cw/cecwp/General_guidance/EGM02-06M.pdf.

vessel costs are used in economic analysis of deep draft navigation projects such as the Portsite proposal. They are presumed to represent annualized values, incorporating life cycle cost adjustments, necessary and appropriate to depict costs over the 50-year project economic life, such as adjusting for the salvage value of vessels removed from service. The Corps requires use of the vessel costs exactly as presented in the EGM or other official Corps sources. Implicit in the official costs is an interest rate which can differ from other report interest rates due to the time of preparation.

The daily operating cost of each vessel was converted to a daily cost per ton at various levels of light loading, in order to allow identification of the more economical vessel at a required draft limit or at a given required deadweight tonnage. Immersion rates were selected from data in EGM 02-6, the latest EGM with the necessary detail.

The more economical vessel at a given draft is often not the more economical vessel for a given deadweight tonnage. In some bulk commodities at certain destination ports, tonnage requirements are a principal concern and will frequently be the determinant of the most economical vessel for that port. It was learned that such maximum load restrictions do not exist for any of the first ports of call for vessels departing from Portsite; therefore, cost per ton at increments of depth are the determinant of the best suited vessel except when shipments in amounts of 44,000 dwst or less are required. The actual number of vessels was estimated, based on using the most economical vessel to deliver to specified destinations. Fleet projections were made for both the with-project and without-project condition, and the finding is that the cases are identical.

**Bulk Shipping Profile**. The United States continues to depend primarily on ocean borne shipments for its international trade. As the world's largest trading nation, the United States exports and imports about one-fourth of global merchandise trade in value annually (over $2 trillion in 2000). The largest part of this merchandise trade—over 1.1 billion tons of cargo—is moved by water. Another billion tons of cargo, 23% of the nation's total, is carried in domestic waterborne movements. Some current projections for the year 2020 estimate that U.S. foreign trade in goods may grow to four times today's value and almost double its current tonnage.

The United States once relied on a huge fleet of relatively small ships to provide the commercial and sealift shipping capacity appropriate for its trade. Since the end of World War II, the U.S. flag merchant fleet has been in a continual state of decline. The United States now ranks 18th in number of oceangoing vessels and 11th on a deadweight tonnage basis. Nevertheless, average vessel tonnage capacity has increased, while changes in maritime technology and reductions in crew sizes have contributed to a contraction of the industry's supply of vessels and manpower. Today, the U.S. flag foreign trade liner fleet carries over 42% more cargo than in 1970, but in fewer, larger vessels. This trend is even more evident in the foreign flag fleet, which provides service from U.S. ports to foreign ports at a lower cost than the U.S. flag fleet.

**Flags of Convenience**. All ships must be registered to one of the nations of the world in order that responsibility for violations of international law and convention may be assigned. These ships then fall under the jurisdiction of their nation of registry. Shipping organizations adopted the practice of shopping around for nations that would give them the best deal on taxes, wages, and legal restrictions. They "conveniently" register their ships with these countries, which include Liberia—which has the world's largest shipping fleet—Panama, Honduras, the Bahamas, Vanuatu, and the Marshall Islands. The United States has safety, tax, wage, and working condition requirements that tend to increase the cost of being registered as a U.S. flag vessel. Most of the world fleet outside of Jones Act vessels (U.S. flag required to serve one U.S. port from another U.S. port) are flagged in countries other than the United States.

**Types of Merchant Carriers**. Liner or berth service is defined as a scheduled operation by a common carrier whose ships operate on a predetermined and fixed itinerary over a given route, at relatively regular intervals, and are advertised considerably before sailing in order to solicit cargo from the public. These common carriers provide transportation on fixed schedules and at rates (tariffs) made electronically available to the public. The liner fleet includes full containerships, partial containerships, lighter aboard ships (LASH), roll-on/roll-off (Ro/Ros), and barge-carrying vessels. Vessels in the liner trades carry high-value cargo, as to its worth, and multi-faceted cargo, as to its physical description, including packaged goods, and refrigerated fruit and vegetables.

One very important aspect, inherent in the liner shipping industry, is the conference system. Conferences, first formed in 1875 by the steamship lines to prevent predatory rate wars, are defined as associations of water common carriers, which meet at stated intervals to discuss matters of interest and to set tariffs, or rates and rate structures. Members of the conference agree to abide by the rules of the conference with regard to the rates that will be charged.

**Bulk Trades**. The bulk shipping industry's economic environment is much different from the liner industry. Bulk shipping is much less structured and not organized along schedules. The bulk vessels which carry mainly oil, chemicals, and raw materials, such as ore concentrate, follow cargos. This means that an operator does not have a fixed schedule of sailings for his vessel and will employ it where and when he can get a cargo. Bulk service is generally not provided on a regularly scheduled basis, but rather as needed, on specialized ships transporting a specific commodity. Cargoes are shipped unpackaged, and loaded using facilities designed for a specific type of commodity.

The rate structure is not set in deliberations by a group of operators as they are in a liner conference framework. Rather, the rates are set by forces of supply/demand for the commodity and for the vessel. Brokers are the key to making contracts, and many contracts are executed over the telephone. For bulk vessels the operators are contract carriers, under either time or voyage arrangements chartered by the shipper.

Bulk carriers can be divided primarily into two principal types of ownership. The first is the proprietary owner, whose costs may be calculated as part of the parent corporation's operating expenses. To minimize these costs the proprietary owner may try to offer his ship for charter on the ballast leg of a voyage, but its primary purpose is to serve the parent company. The other type is the privately owned shipping company, which sells its transportation service as the market dictates. Both types are contract carriers, which charter ships on a long-term or short-term voyage or other basis.

**Tramp Service**. A tramp ship, in traditional terms, is one that operates on an irregular or non-scheduled basis from one port of lading to one port of discharge, lifting one dry cargo commodity, usually of low value, without mark or count, and from one shipper to one consignee. Some vessels in irregular service may carry mixed cargoes of bulk and packaged goods. The tramp operator does not usually hold himself out as a common carrier, and his ship is free to operate anywhere on any terms, not infrequently being chartered out on time terms. Rates vary from day to day, depending upon supply and demand.

**Bulk Fleet Serving Portsite.** The following table compares the characteristics of the two sizes of foreign flag bulk carriers in use at Portsite, and the foreign flag tanker, which is anticipated to be in use in the future after a dock-side unloading facility is made available. The fleet is made up of only Handysize and Panamax size carriers, but there are many vessels in the world fleet which fit the description. Vessels calling at Portsite are provided under the management of two ship owners; however, ships used are not necessarily owned by the two companies nor are specific ships committed ahead of time to specific routes, schedules, or rates.

**Table 21. Portsite Fleet Characteristics—Foreign Flag Carriers**

| | BULKER 44,000 DWST | BULKER 77,000 DWST | TANKER 55,000 DWST |
|---|---|---|---|
| Length | 632' | 720' | 650 |
| Beam | 93 | 105 | 107 |
| Draft | 37' | 45' | 40 |
| ST Per Inch Immersion | 119 | 169 | 141 |
| HP | 10,863 | 13,296 | 11,236 |
| Service speed | 14 Kt, 16 Mph | 14 Kt, 16 Mph | 14 Kt, 16 Mph |

The tanker shown in the table will ultimately replace a tug and barge operation for the delivery of fuel. The selected tanker size is 55,000 dwst, and it will deliver 4 loads at 49,930 tons per trip, or 58,746,700 gallons per year. With the vessel light loaded at 49,930 tons, it will draw about 37 ft of its fully loaded 40 ft design draft. The tanker selection is consistent with data in Corps EGM 00-06 and represents a vessel size most practical and economical for delivering the annual fuel supply in 4 trips. A 38,000 dwst vessel could be used, but it would result in an added cost for an additional trip to deliver the annual supply; there would also be the added delay cost and adverse effect on throughput associated with adding one vessel to the queue. The 55,000 dwst vessel is more versatile in that it allows adequate tanker capacity in one load to fill the 15,000,000 gallon tank farm. This is a requirement because, with a Red Dog Mine fuel consumption rate of about 2,000,000 gallons per month, the tank farm must be left full after the last delivery of the season.

For the 55,000 dwst tanker loaded with 49,930 tons of fuel, the cost per ton per day is $.39 when the vessel is at sea. Variations in vessel cost will have an impact on the benefit evaluation and are therefore reported in the sensitivity analysis section of this feasibility report.

It is possible to combine fuel types with a vessel properly set up for it.[54] In general tanker vessels are able to carry a variety of fuels on the same voyage, depending primarily on the

[54] Personal communication in July 2002 with Brian Trenhaile, Naval Architect and Marine Engineer, Hawaii Marine Company, Kaneohe HI.

characteristics of port regulations. Such multi-fuel deliveries are common among west coast ports.[55]

TCAK makes all concentrate shipping arrangements through two ship owners and covers the total shipping cost from origin to destination in order to maintain maximum control over the schedule. The company makes estimates of sales and develops a preliminary vessel plan, updating it as necessary through the year. Vessels are ordered in connection with the tonnage expected to be delivered to specific ports. It is company policy to maximize the capacity of each vessel used, and ordinarily, any fractional load is a last unit of a larger multi-vessel delivery.

**Vessel Cost**. The Corps' vessel cost database contained vessels typical in terms of draft, deadweight tonnage, and length to those in use at Portsite, with the exception that the database does not contain costs for a 77,000 dwst foreign flag bulk carrier, so the cost was arrived at by interpolating available data. Vessel characteristics are summarized in the following tables:

**Table 22. Cost Summary—Foreign Flag Carriers, FY 2004 Data**

| | 44,000 DWST BULKER | 77,000 DWST BULKER | 55,000 DWST TANKER |
|---|---|---|---|
| Total Daily Cost at Sea | $14,440 | $17,448 | $19,344 |
| Total Daily Cost in Port | $10,160 | $12,252 | $15,184 |
| Total Hourly Cost at Sea | $601.67 | $727.67 | $806.00 |
| Total Hourly Cost in Port | $423.33 | $510.50 | $632.67 |

**Vessel Cost Advantage**. The summary of costs for the bulk carriers shows that the larger carrier is more costly to operate. This fact alone is of little consequence, because it is cost per ton that is important, and the cost per ton does not always favor the larger carrier. This is because for some commodities and some ports, shipments are made in less than full shiploads. However, in cases where ships are forced to sail at light loaded drafts, the larger carrier generally has a cost advantage. In contrast, where two vessels compete to deliver a unit load less than the maximum load the vessel can carry, the smaller carrier generally has an advantage. In other words when vessel cost per ton is compared at a set draft, say 36 ft, the larger carrier usually has an advantage, because it carries a greater tonnage at a given draft. However, if the commodity is limited to a specified number of tons, say 30,000 swt, the smaller carrier has an advantage, because it benefits from a lower total cost. These relationships are demonstrated:

[55] Captain E. G. Duarte, E.G Duarte and Associates, Naval Architect, Personal communication, July 2002.

**Table 23. Comparing The Cost Of A 77,000 dwst Bulk Carrier With The Cost Of A 44,000 dwst Bulk Carrier At A Specified Load**

| LOAD | 77,000 DWST | 44,000 DWST |
|---|---|---|
| | $ ton/day | $ ton/day |
| 77,000 | $0.23 | n/a |
| 44,000 | $0.40 | $0.33 |
| 40,000 | $0.44 | $0.36 |
| 36,000 | $0.48 | $0.40 |
| 32,000 | $0.54 | $0.45 |
| 28,000 | $0.62 | $0.52 |
| 24,000 | $0.73 | $0.60 |
| 20,000 | $0.87 | $0.72 |
| 16,000 | $1.09 | $0.90 |

Bold figures are the least cost

**Table 24. Comparing The Cost Of A 77,000 dwst Bulk Carrier With The Cost Of A 44,000 dwst Bulk Carrier At A Specified Draft**

| DRAFT | 44,000 DWST | | 77,000 DWST | |
|---|---|---|---|---|
| | Tons Rated | $ ton/day | Tons Rated | $ ton/day |
| 18' | 16,900 | $0.85 | 22,200 | $0.78 |
| 21' | 21,200 | $0.65 | 28,300 | $0.62 |
| 24' | 25,400 | $0.57 | 34,400 | $0.51 |
| 27' | 29,700 | $0.49 | 40,500 | $0.43 |
| 30' | 34,000 | $0.42 | 46,600 | $0.37 |
| 33' | 38,300 | $0.38 | 52,700 | $0.33 |
| 36' | 42,600 | $0.34 | 58,800 | $0.30 |
| 37' | 44,000 | $0.33 | 60,800 | $0.29 |
| 40' | | | 66,900 | $0.26 |
| 42' | | | 70,900 | $0.25 |
| 45' | | | 77,000 | $0.23 |

**Present Fleet Mix**. The history of DMT operations from 1996 thru 1999 shows the mix of vessels to be 67% Panamax and 33% Handysize. Each year the trend to use the larger carriers becomes more pronounced. The Panamax carriers provide deliveries at a lower cost, but the Handysize carriers are also necessary, because they deliver to ports unable to accommodate Panamax vessels or otherwise unable to handle the Panamax sized bulk delivery. In some cases Panamax carriers call at one port and deliver a partial load, then call at one or two other nearby ports to leave partial loads there as well. Use of Panamax carriers to serve two nearby destinations, unable to handle the complete ship load, is more cost effective than using two Handysize carriers making two separate trips. The Panamax carrier is more cost effective, serving a single destination that is able to accept loads between 44,000 and 77,000 swt. This leaves the Handysize carriers as preferred for either single or multiple destinations that are not able to accommodate loads over 44,000 swt or drafts over 37 ft.

**Table 25. Deep Draft Vessel Dimensions—Vessels Calls, 1996–1999**

| Ship's Name | DWT | Length Overall | Beam | Maximum Draft | Capacity |
|---|---|---|---|---|---|
| | (Long Tonnes) | (ft) | (ft) | (ft) | (SWT) |
| Vienna Wood N (now Vienna Wood) | 40,876 | 587 | 85.5 | 33.5 | 39,000 |
| Sunny Succes | 42,203 | 591 | 100.1 | 36.7 | 40,000 |
| Alam Selamat | 39,110 | 593 | 100.2 | 35.9 | 40,000 |
| Fairwind Express (now Millenium Express) | 39,055 | 593 | 100.2 | 35.9 | 40,000 |
| Taxiarhis P | 39,013 | 593 | 100.2 | 35.9 | 36,679 |
| Pacific Champ | 43,229 | 607 | 100.1 | 36.8 | 42,000 |
| Bunga Melor Dua | 43,108 | 607 | 100.1 | 36.8 | 41,700 |
| Sabrina Venture | 45,736 | 609 | 99.7 | 38.1 | 44,250 |
| Griffin | 45,734 | 609 | 99.8 | 38.1 | - |
| Sabrina Venture | 45,736 | 609 | 99.7 | 38.1 | 44,600 |
| Coral Halo (now Coral Gem ) | 45,292 | 622 | 100.1 | 37 | 65,636 |
| Diamond Halo | 46,489 | 622 | 100.1 | 37 | - |
| Pisces Explorer | 38,584 | 623 | 93.2 | 36.2 | 40,000 |
| Oriental Express | 45,342 | 623 | 105.6 | 35.8 | 43,500 |
| Grand Cherry | 45,731 | 623 | 101.7 | 38.1 | 44,500 |
| Tai Shun Hai | 47,378 | 623 | 105.6 | 38.5 | 45,550 |
| Pretty Prosperity | 47,051 | 623 | 101.7 | 36.1 | 45,143 |
| Multi-purpose 2 (now Monarch ) | 41,520 | 649 | 105.6 | 32.2 | 40,000 |
| Gao Qiang | 45,400 | N/A | 99.7 | 35.9 | 44,544 |
| Belgrado (now Seaboni) | 51,400 | 726 | 105.9 | 40.8 | 72,500 |
| Baron Trader (now Prime Condition) | 68,600 | 735 | 105.6 | 43.3 | 63,000 |
| Mui Kim | 68,774 | 736 | 105.8 | 43.3 | 67,300 |
| Sea Success (now Miyama I) | 69,755 | 738 | 105.8 | 43.3 | 75,565 |
| Mass Enterprise | 69,555 | 738 | 105.6 | 43.5 | 64,000 |
| Pacific Fortune | 70,349 | 738 | 105.8 | 43.5 | 76,000 |
| Mass Wits | 67,516 | 738 | 105.6 | 43.3 | 63,000 |
| Royal Pilot | 70,165 | 738 | 105.8 | 43.6 | 75,500 |
| Achilles | 68,779 | 738 | 105.6 | 43.4 | 67,100 |
| Navios Mariner | 69,618 | 738 | 105.8 | 43.5 | 58,000 |
| Maritime Mosaic (now Maritime Dignity) | 73,350 | 738 | 105.8 | 45.5 | 70,000 |
| Channel Fortune (nowMass Success) | 69,346 | 738 | 105.8 | 45.4 | 58,500 |
| Halla Ace (now Panthea ) | 73,390 | 738 | 105.8 | 45.2 | 72,000 |
| Orange Phoenix (now Nicholas Smile) | 69,561 | 738 | 105.6 | 43.5 | 68,500 |
| Ever Mighty | 75,400 | 738 | 105.8 | 47 | 72,986 |
| Powhatan | 70,153 | 738 | 106 | 43.5 | 68,600 |
| Oceanic Star (now Unisterling) | 69,616 | 738 | 105.6 | 43.4 | 58,120 |
| Sincere Nova | 71,982 | 738 | 105.8 | 44.2 | 70,500 |
| Oceanic Enterprise | 71,259 | 738 | 105.6 | 44.8 | 69,500 |
| Fu Man | 71,350 | 738 | 105.6 | 44.1 | 69,400 |
| Shekou Sea | 72,394 | 738 | 105.6 | 44.3 | 71,400 |
| Atlantic Nova (now Golden Bridge) | 69,050 | 738 | 105.8 | 43.6 | 45,000 |
| Eastern Queen | 70,196 | 738 | 105.8 | 40.7 | 68,130 |
| Huang Shan Hai | 73,596 | 738 | 105.8 | 46.2 | 71,600 |
| Rio Verde | 69,562 | 738 | 105.6 | 43.4 | 58,300 |
| Nordmax | 72,500 | 738 | 105.6 | 45.3 | 70,715 |
| Paiute | 71,417 | 738 | 106 | 43.5 | 68,252 |
| Noble Star | 73,740 | 738 | 105.8 | 40 | 70,759 |
| Sincere Nova | 71,982 | 738 | 105.8 | 44.2 | 70,759 |
| Emerald Indah | 77,734 | 738 | 119.7 | 42.1 | 76,202 |

| Ship's Name | DWT | Length Overall | Beam | Maximum Draft | Capacity |
|---|---|---|---|---|---|
| Oceanic Explorer | 69,971 | 738 | 105.6 | 43.4 | 67,300 |
| Austac Nova | 69,118 | 738 | 105.6 | 43.6 | 65,860 |
| Navios Dynasty (now Dynasty) | 70,242 | 738 | 106 | 43.6 | 67,355 |
| China Pride | 65,655 | 440 | 105.6 | 43.1 | 55,000 |
| Madonna Lilly (now Striggla) | 64,747 | 746 | 105.1 | 41.1 | 61,433 |
| Angel | 60,250 | 747 | 105.6 | 41.9 | 57,000 |
| Lucky Bulker (now Panktokrator) | 71,740 | 766 | 105.8 | 44.8 | 75,700 |
| Navios Bulker | 69,737 | 781 | 105.9 | 43.5 | 64,000 |
| Evgenia | 68,427 | 781 | 105.6 | 43.5 | 75,000 |
| Mercury K | 63,183 | | 105.6 | 40 | 70,000 |

**Deep Draft Vessel Itinerary**. Examination of all the destination ports, served from 1996 through 1999, revealed that the ports able to accommodate fully loaded Panamax carriers received 77% of the tonnage actually declared as carried. When tonnage to all of the other ports that are actually capable of accepting partial deliveries by Panamax, more economically than delivery by Handysize, are added, then deliveries by Panamax vessels become 87% of the total tons declared. The major routes used by the deep draft carriers are illustrated in figure 4, and details of vessel itineraries are shown in the accompanying table.

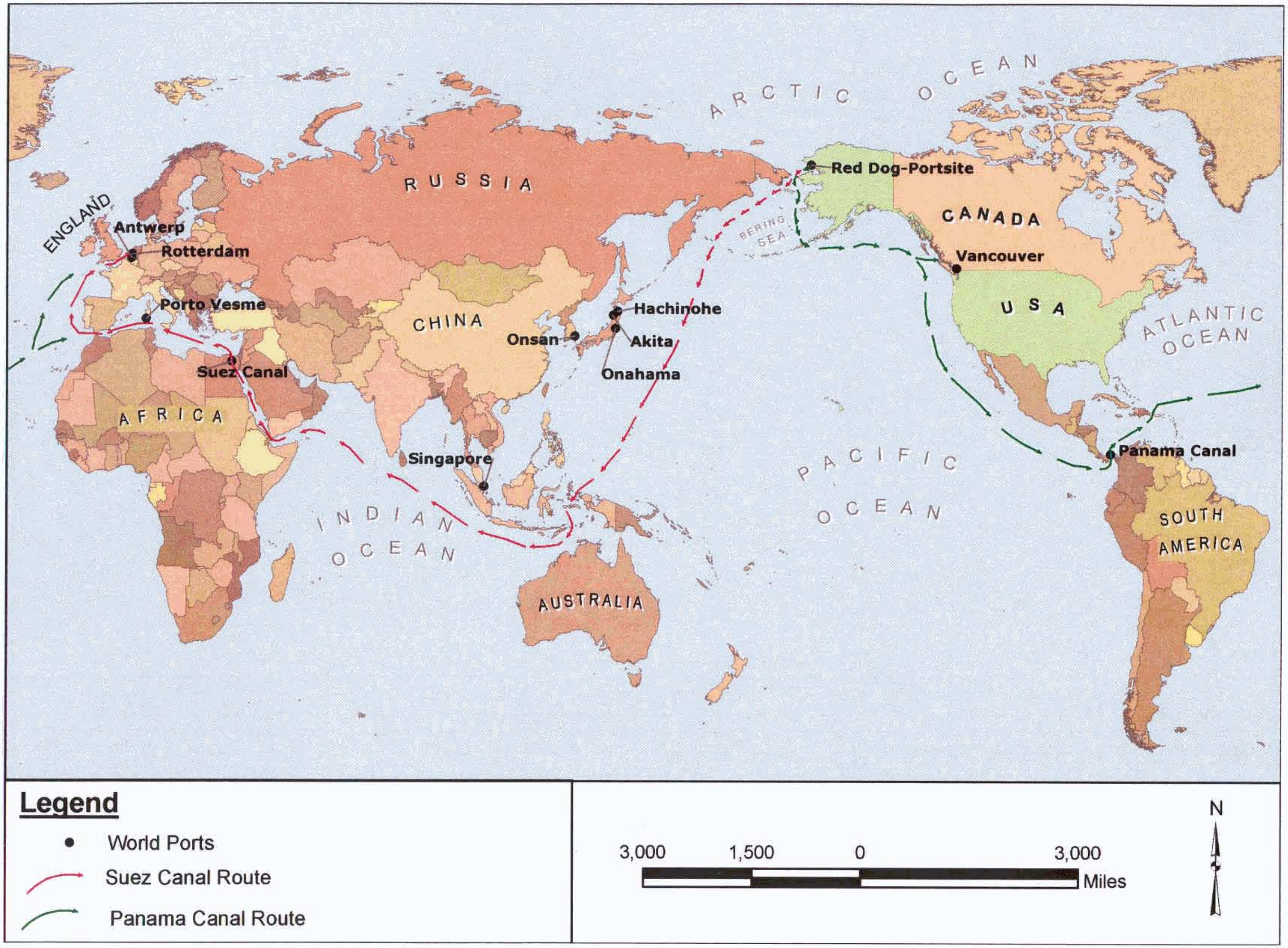


Figure 4. Major Shipping Destinations And Routes

## Table 26. Deep Draft Vessel Trips, 1996–1999

| Ship's Name | Class | Name of First Port | Name of Second Port | Name of Third Port |
|---|---|---|---|---|
| Coral Halo (now Coral Gem ) | Handysize | Antwerp | Aviles | |
| Diamond Halo | Handysize | Townsville | Hobart | |
| Pisces Explorer | Handysize | Hachinohe | Akita | Shikama |
| Pisces Explorer | Handysize | Onsan | Dalian | |
| Oriental Express | Handysize | Hachinohe | Akita | Hikoshima |
| Pretty Prosperity | Handysize | Bukpyung | Onsan | Huangpu |
| Grand Cherry | Handysize | Bukpyung | Onsan | Hikoshima |
| Tai Shun Hai | Handysize | Hikoshima | Bukpyung | Onsan |
| Pretty Prosperity | Handysize | Hachinohe | Akita | Shikama |
| Pretty Prosperity | Handysize | Shikama | Onsan | Lianyungang |
| Multi-purpose 2 (now Monarch ) | Handysize | Hachinohe | Akita | Bukpyung |
| Gao Qiang | Handysize | Bukpyung | Onsan | |
| Gao Qiang | Handysize | Shikama | Onsan | Tianjin |
| Belgrado (now Seaboni) | Panamax | Vancouver | | |
| Baron Trader (now Prime Condition) | Panamax | Antwerp | | |
| Mui Kim | Panamax | Vancouver | | |
| Sea Success (now Miyama I ) | Panamax | Vancouver | | |
| Mass Enterprise | Panamax | Antwerp | | |
| Pacific Fortune | Panamax | Vancouver | | |
| Mass Wits | Panamax | Antwerp | | |
| Royal Pilot | Panamax | Vancouver | | |
| Achilles | Panamax | Vancouver | | |
| Navios Mariner | Panamax | Nordenham | | |
| Maritime Mosaic (Now called Maritime Dignity) | Panamax | Vancouver | | |
| Channel Fortune (now Mass Success ) | Panamax | Antwerp | Aviles | |
| Halla Ace (now Panthea ) | Panamax | Vancouver | | |
| Joyous Society | Panamax | Antwerp | | |
| Orange Phoenix (now Nicholas Smile ) | Panamax | Vancouver | | |
| Ever Mighty | Panamax | Vancouver | Antwerp | |
| Powhatan | Panamax | Antwerp | | |
| Oceanic Star (now Unisterling ) | Panamax | Nordenham | | |
| Sincere Nova | Panamax | Rotterdam | | |
| Oceanic Enterprise | Panamax | Antwerp | Aviles | |
| Luigi d'Amato | Panamax | Vancouver | | |
| Fu Man | Panamax | Vancouver | | |
| Shekou Sea | Panamax | Vancouver | | |
| Atlantic Nova (now the Golden Bridge ) | Panamax | Hachinohe | Akita | Shikama |
| Eastern Queen | Panamax | Vancouver | | |
| Huang Shan Hai | Panamax | Antwerp | | |
| Rio Verde | Panamax | Nordenham | | |
| Nordmax | Panamax | Antwerp | | |
| Paiute | Panamax | Antwerp | Aviles | |
| Noble Star | Panamax | Vancouver | | |
| Sincere Nova | Panamax | Antwerp | Kokkola | |
| Emerald Indah | Panamax | Vancouver | | |
| Oceanic Explorer | Panamax | Rotterdam | | |
| Austac Nova | Panamax | Antwerp | Aviles | |
| Navios Dynasty (now Dynasty ) | Panamax | Vancouver | | |
| China Pride | Panamax | Antwerp | | |

| Ship's Name | Class | Name of First Port | Name of Second Port | Name of Third Port |
|---|---|---|---|---|
| Madonna Lilly (now Striggla) | Panamax | Rotterdam | | |
| Angel | Panamax | Rotterdam | | |
| Lucky Bulker (now Pantokrator ) | Panamax | Vancouver | | |
| Navios Bulker | Panamax | Rotterdam | | |
| Evgenia | Panamax | Vancouver | | |
| Mercury K | Panamax | Antwerp | | |
| Vienna Wood N (now Vienna Wood) | Handysize | Onsan | | |
| Vienna Wood N (now Vienna Wood) | Handysize | Hachinohe | Akita | Bukpyung |
| Sunny Succes | Handysize | Onsan | Dalian | |
| Alam Selamat | Handysize | Korea | | |
| Fairwind Express (now Millenium Express ) | Handysize | Akita | Hachinohe | Onahama |
| Taxiarhis P | Handysize | Antwerp | | |
| Pacific Champ | Handysize | Shikama | Onsan | |
| Pacific Champ | Handysize | Bukpyung | Onsan | |
| Bunga Melor Dua | Handysize | Vancouver | | |
| Sabrina Venture | Handysize | Bukpyung | Onsan | |
| Griffin | Handysize | Antwerp | Porto Vesme | |
| Sabrina Venture | Handysize | Hachinohe | Akita | Hikoshima |

**Fleet Trends in the Without-Project Condition**. In the without-project condition, commodity throughput is limited, thus nullifying the need for fleet additions. Notwithstanding this, there is a long-term trend toward larger vessels, evident in the 934 bulk carriers in the world fleet. Data indicates that there has been a progressive size increase among Panamax dry bulk carriers.[114] Initially development centered around 50,000–55,000 dwst, which were essentially ore carrier derivatives. By the mid 1970s the typical unit size was around 60,000 dwst. The new vessels, during the first half of the 1980s, grew to 65,000 dwst, then to 69,000 dwst in the late 1980s, and now the standard is 72,000 dwst. The percentage of vessels in the Panamax class has been growing at a rate faster than the Handysize class. This vessel trend is anticipated to continue because of the demonstrated favorable economics of the larger vessels.

In the without-project condition, throughput tonnage is anticipated to approach 1,544,000 swt, and it is anticipated that vessel use patterns will adjust toward an optimum mix of Handysize and Panamax vessels. The optimum mix would be that capable of using Panamax vessels to carry tonnage to all of the ports, capable of accepting whole or partial deliveries by Panamax vessels; these ports represent 87% of the tonnage delivered. Adjusting for an average short ton shipment of 39,500 swt for Handysize and 65,800 swt for Panamax, this distribution of tonnage by vessel class translates to 20.4 Panamax vessel loads (1,544,000 annual swt x .87 tonnage to Panamax ports/65,800 average swt per vessel), requiring 20 vessels with 26,300 swt left over. The left over tonnage is most economically carried by a Handysize vessel. Average load was calculated from tonnage declarations for all vessels loaded during 1996 through 1999. Handysize requirements will be 6 vessels (estimated by 5.1 Handysize vessels = 1,544,000 annual swt x .13 Handysize class ports/39,500 average

[114] Clarkson's Bulk Register as a secondary source gleaned from U.S. Army Corps of Engineers Columbia River Channel Deepening feasibility report and EIS, Appendix C.

swt per vessel plus 26,300 partial load swt that were uneconomical for the Panamax vessels, thus providing a 30,000 swt load for one otherwise partially loaded Handysize carrier).

**Table 27. Without-Project and With-Project Conditions (53 ft Channel) Bulk Carrier Vessel Loads 1,544,000 swt**

| | '02 | '10 | '11 | 20 | '30 | '40 | '50 |
|---|---|---|---|---|---|---|---|
| Tanker | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Handysize Size | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Panamax | 20 | 20 | 20 | 20 | 20 | 20 | 20 |

In the above table, the fleet ratio is 0% tanker, 77% Panamax, and 23% Handysize. For the with-project condition at 53 ft, the fleet does not change except to include 4 tankers. At shallower channel depths, light loading is required, and this leads to variation in fleet requirements for channel depths under 53 ft. Fleet percentage distributions are used as input to the shipping simulator, and it generates the actual fleet used for the benefit analysis.

**Fleet Projection for the With-Project Condition.** In the with-project condition the concentrate shipping target is also most likely to level off near 1,544,000 swt. At that tonnage level. the bulk carrier fleet would be nominally the same as in the without-project condition. On average, slightly fewer tons are shipped in the without-project condition, due to inefficiency of the system, so the demand for bulk carriers is marginally less. The with-project condition, however, also includes a regional fuel terminal and calls for addition of a 55,000 dwst tanker making four calls per year.

There is the less likely chance that shipping in the with-project condition could increase to 1,729,000 swt around the year 2011. At either level the distribution of concentrate is anticipated to be carried proportionally by Panamax and Handysize vessels in the 77% / 23% fleet mix, respectively. Based on the "best mix" criteria, the higher tonnage would result in an increase in the number of bulk carriers calling at Portsite to 22.8 (say 23) loads for Panamax vessels and 5.7 (say 6) carried by the Handysize fleet.

**Table 28. With-Project Condition (53 ft Channel) Number of Vessel Loads (1,729,000 swt)**

| | '02 | '10 | '11 | '20 | '30 | '40 | '50 |
|---|---|---|---|---|---|---|---|
| Tanker | 0 | 0 | 4 | 4 | 4 | 4 | 4 |
| Handysize Size | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Panamax | 20 | 20 | 23 | 23 | 23 | 23 | 23 |

The fleet ratio is 12% tanker, 70% Panamax, and 18% Handysize.

**Fleet Mix With a Shallower Channel.** In the with-project condition, there are a number of incremental project depths, which need to be considered in order to identify the NED optimum. As the channel gets shallower, the fleet expands, because some of the vessels will need to be light loaded in order to safely navigate the channel with adequate under-keel clearance. For example when the 53 ft channel (based on a fully loaded Panamax vessel at 45 ft plus 8 ft under-keel)[115] is made 3 ft shallower, Panamax vessels must take a lighter load by

[115] A discussion of underkeel clearance can be found the Hydraulic Design Appendix.

3 ft, while the Handysize carriers still carry a full load. The effect is to require more Panamax vessels while keeping the Handysize constant at least down to their draft limitation of 37 ft plus 8 ft under keel clearance. The following table shows the relation between draft and tonnage for Panamax and Handysize carriers at various drafts.

**Table 29. Draft Comparison**

| PANAMAX | | | HANDYSIZE | | |
|---|---|---|---|---|---|
| FEET | DWST | LOAD@85.5% | FEET | DWST | LOAD@90% |
| 45 | 77,000 | 65,800 | 37 | 44,000 | 39,500 |
| 42 | 70,900 | 60,600 | 36 | 42,600 | 38,300 |
| 40 | 66,900 | 57,200 | 33 | 38,300 | 34,500 |
| 36 | 58,800 | 50,300 | 30 | 34,000 | 30,600 |
| 33 | 52,700 | 45,100 | 27 | 29,700 | 26,700 |
| 30 | 46,600 | 39,800 | 24 | 25,400 | 22,900 |
| 27 | 40,500 | 34,600 | 21 | 21,200 | 19,000 |
| 24 | 34,400 | 29,400 | 18 | 16,900 | 15,200 |
| 21 | 28,300 | 24,200 | | | |

The column titled dwst is a calculation of displacement volume at a specified water line loading, using immersion rates for the design vessel, and as such is a theoretical maximum measurement for the number of tons of cargo a vessel could conceivably carry at a specified load line. It is considered to be a nominal rating. There is ordinarily a notable difference between a vessel's dwst rating and the actual weight of cargo aboard a vessel, because the dwst measure does not account for fuel for the vessel, water, stores, post-manufacture machine areas, trim ballast, bilge wet spaces, or equipment, such as deck cranes, added after manufacture.

The established practice of shipping out of Portsite is to load the vessels, based not on what they are able to take, but based on what the buyers at the destination ports have agreed to take. In many cases a ship will make several calls to offload a combination of deliveries, but the total load will still correspond with the order volume, which for the reasons listed above, is not necessarily the vessels available dwt capacity. To provide a consistent metric for the manner in which the vessels are used, each sailing over a period of four years was examined to determine the vessel load pattern; it was found, with a minor amount of variation, that the average payload was equal to 85% of the Panamax capacity and 90% of the Handysize capacity. Bulk carrier load factors in the 85%–90% range are actually quite high, because it is impossible to exceed 100%, and a 90% factor would represent a practical range of vessel loads between 80%–100%. A disparity between vessel dwt rating and cargo payload is typical of bulk carrier operations, due to the many chance events involving ship availability, customer needs, and mine operations; however, in the case of Portsite, the average difference is quite small.

In the forgoing table the column titled LOAD is the estimated average amount of concentrate that would typically be carried aboard a light loaded vessel. The estimated LOAD is derived by extending the historical proportionate LOAD factors of 85% and 90%, respectively, to vessel dwt at various draft marks. Given the above relationship between draft and tons loaded, the number of vessels needed for each channel depth is estimated, proportionate to the required light loading. For example, given the tonnage anticipated to be shipped as

1,544,000 swt and a 50 ft channel, a vessel light loaded 3 ft yields an average payload of 60,600 swt, so (1,544,000 x .87 swt of concentrate to Panamax ports/60,600 swt per vessel = 22.2); this is 22 Panamax vessels with 12,100 swt left over, effectively topping off a Handysize vessel, which would otherwise be light loaded.

The following tables display the relation between tons shipped and vessels required under various light loading scenarios. The examples display the fleet required to ship 1,729,000 swt after 2012, although the most likely case is continuation of 1,544,000 swt through the entire planning period. Because of the possible increased tonnage anticipated in 2012, the estimate for 2012 comes out to 24.8 (say 25) Panamax vessel loads. There is a requirement for 5.7 (say 6) Handysize carriers.

**Table 30. With-Project Condition (50 ft Channel) Number Of Vessel Loads (1,729,000 swt)**

| | '02 | '10 | '11 | '20 | '30 | '40 | '50 |
|---|---|---|---|---|---|---|---|
| Tanker | 0 | 4 | 4 | 4 | 4 | 4 | 4 |
| Handysize Size | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Panamax | 22 | 22 | 25 | 25 | 25 | 25 | 25 |

The fleet ratio is 11% tanker, 71% Panamax, and 17% Handysize.

**Table 31. With-Project Condition (47 ft Channel) Number Of Vessel Loads (1,729,000 swt)**

| | '02 | '10 | '11 | '20 | '30 | '40 | '50 |
|---|---|---|---|---|---|---|---|
| Tanker | 0 | 4 | 4 | 4 | 4 | 4 | 4 |
| Handysize Size | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Panamax | 24 | 24 | 27 | 27 | 27 | 27 | 27 |

The fleet ratio is 10% tanker, 74% Panamax, and 16% Handysize.

At a 47 ft channel depth the displacement of each of the Panamax vessels is lighter by an average of about 10,000 tons, allowing it to meet the maximum allowable draft of 39 ft and thus provide for a stipulated 8 ft under keel clearance. With the Panamax vessels loaded at 39 ft, 24 vessels will be required. By year 2011 tonnage increases and 27 vessels are required. With 27 Panamax vessels loaded, there are no fractional loads left over that would favor substituting Handysize vessel for a partially loaded Panamax.

In years when shipping disruptions occur and the projected commodity flow is not fully achieved, the number of vessels departing Portsite will be reduced accordingly. These shortfall years are not accounted for in the projection, because they are derived by the simulator. The fleet projection is one set of inputs to the simulator.

**Simulator Application**. The foregoing derivation of vessels needed is a theoretical least cost mix of dry bulk carriers within known port constraints. Actual real life data and simulation output data will most likely differ from the theoretical least cost mix. There are many reasons, including randomness in the model and competing needs for the fleet, which presents vessel owners with a choice of earning opportunities for specific vessels in real life. These inevitable deviations from the least cost mix are also complicated by the vessels being constantly on the move and hence at varying distances from Portsite when needs are announced.

The dry bulk fleet mix percentages derived from the least cost fleet exercise is used as input to the simulator, and the simulator uses them to select a specific vessel size for a particular shipment. Percentages for the tankers are not shown, because they follow a specified schedule. The simulation model chooses ships randomly from the ship mix inputs (e.g., 77% Panamax and 23% Handysize) to arrive at the terminal. As the model finishes loading each ship, it checks to see if the target throughput has been met. The criteria for the target being achieved is, specified model input, such as the total ore loaded being within x% of the target. Once the target throughput loaded is within the target range, over or under, the model stops for the year.

Therefore, as history shows, there are some Handysize carriers sailing to Panamax ports and some Panamax carriers sailing with less than a full load. The overall effect is for the simulator to generate a fleet for each simulation year and calculate an average fleet size. Given the average annual fleet size generated within the simulator, the average annual total is disaggregated, using the mix representative of the lowest overall operating cost, as shown for various cases (alternative plans) in the following table. The simulator was run for six specific plan configurations, and data from these cases was transferred to analysis of other plans with appropriate adjustments.

**Table 32. Vessel Mix Percentages[116] Applied to Simulator Output 1,544,000 swt Projection**

| CASE | PANAMAX % | HANDYSIZE % | TANKER # |
|---|---|---|---|
| W/O Project | 77% | 23% | 0 |
| Alt 2 – 3 Barges | 77% | 23% | 0 |
| Alt 3 - BW | 77% | 23% | 0 |
| Alt 4 – 3 Barges + BW | 77% | 23% | 0 |
| Alt 11 CH+TR (w/F) | | | |
| CH+TR 47' | 80% | 20% | 4 |
| CH+TR 50' | 79% | 21% | 4 |
| CH+TR 53' | 77% | 23% | 4 |

**Table 33. Vessel Percentages Applied to Simulator Output 1,729,000 swt Projection**

| CASE | PANAMAX % | HANDYSIZE % | TANKER # |
|---|---|---|---|
| W/O Project | 79% | 21% | 0 |
| Alt 2 – 3 Barges | 79% | 21% | 0 |
| Alt 3 - BW | 79% | 21% | 0 |
| 3 Barges and BW | 79% | 21% | 0 |
| Alt 11 – CH+TR (w/F) | | | |
| CH+TR 47' | 82% | 18% | 4 |
| CH+TR 50' | 81% | 19% | 4 |
| CH+TR 53' | 79% | 21% | 4 |

[116] See Table 27, 28, 30, and 31 for number of vessels.

**Destination Port Characteristics**. For purposes of this report, notable port characteristics are those factors which tend to categorize the port as more suitable for Panamax or Handysize service. The main limitations are depth at dockside and limitations on tonnage that can be handled. Characteristics of the destination ports are summarized below.

**Table 34. Destination Port Characteristics Suitability For Panamax Or Handysize**

| PORT ROTATION | DEPTH | DISTANCE | COMMENTS |
|---|---|---|---|
| **1st CALL** | | | |
| ONSAN | 39 | 3,680 | 20,000 ton cap - ok draft for panamax 1st call, S Korea |
| HACHINOHE | 40' EST | 2,880 | 50,000 ton design since 96, Japan, Handysize port |
| KOREA | 37 MIN | 3,520 | Judged as 1st port call for fully loaded Handysize |
| AKITA | 37 MIN | 3,200 | Used as 1st port call full loaded Handysize, Japan |
| ANTWERP | 41-51.5 | 12,160 | Depth based on tide, ok panamax, Belgium |
| SHIKAMA | 37 MIN | 4,000 | Takes 1st call fully loaded Handysize, Japan |
| BUKPYUNG | 37 MIN | 3,680 | Takes 1st call fully loaded Handysize, Korea |
| TOWNSVILLE | 39 | 6,480 | OK fully loaded Handysize, Australia |
| HIKOSHIMA | 37 MIN | 3,440 | Takes 1st call fully loaded Handysize, Japan |
| VANCOUVER | UNLIMITED | 2,880 | OK fully loaded panamax. Canada |
| ROTTERDAM | 75 | 12,400 | OK fully loaded panamax, Holland |
| NORDENHAM | 48 | 12,480 | Depth at high tide,OK panamax light, 1st call, Germany |
| **2nd CALL** | | | |
| DALIAN | 19-39 | 4,160 | 50,000 GRT max Handysize size 2nd call, Japan |
| PORTO VESME | varied | 11,520 | Handysize size 2nd call, Sardinia Italy |
| AVILES | 24' – 32.5' channel | 10,748 | Panamax 2nd call, Spain |
| HOBART | 49' entrance | 6,365 | Panamax, 2nd call, New Zealand |
| KOKKOLA | 42' | 12,800 | Panamax 2nd call, Finland |
| **3rd CALL** | | | |
| ONAHAMA | 32.5' | | 3rd call Handysize, China |
| HANGPU | varied | | 3rd call Handysize, China |
| LIANYUNGANG | 32-37 | | 35,000 DWT MAX 3rd call Handysize, China |
| TIANJIN | 29-39 | | 50,000 DWT MAX 3rd call Handysize, China |

The mileage figures are estimates that were scaled from a globe and verified by comparing selected measurements against shipping routes and mileages printed on a map of the world published by Department of Defense. Distances were also estimated by multiplying the number of days of trip duration by the vessel standard service speed noted in *Fairplay*. This later estimate resulted in greater distances by about 14%–25%, depending on the destination. Neither measurement is regarded as being exact. Differences in the estimates happen, because service speeds are ordinarily not the actual speed maintained throughout the trip, and sailing routes are not necessarily exact lines, applying to every vessel and all conditions in the same manner. The distance estimates were not refined, because the mileages do not enter directly into the economic analysis of concentrate shipments. The shipping costs and benefits are tied to vessel cost per day and average days in route from actual records.

# 5.0 DEDICATED FLEET TUG AND BARGE SAVINGS

**Purpose**. This section of the feasibility report examines the type of barge and tug equipment that have been in use at Portsite, the manner in which they are used, and their cost. The information developed in this section is used to estimate the equivalent annual NED costs of the equipment in the without-project and with-project conditions.

**Tug and Barge Equipment**. The Portsite barge terminal is able to accommodate two Foss Maritime self-unloading barges that are maneuvered into place by use of two of four tugs employed at the site, also owned by Foss Maritime. After being loaded by the shoreside conveyor at a rate of about 1,660[117] swt per hour, the barges are towed to bulk carriers anchored about 5 miles offshore where the self-unloading machinery transfers the barge load to the deep draft carrier. About 7–12 barge loads are required to fill a ship, depending on vessel size.

The barges, Kivalina and Noatak, are 5,500 swt, custom designed and built, non-ice class units under long-term contract to TCAK. The barges have fabric covers for dust control and use front end loaders (FEL), operating on the deck, to feed the unloading system, which is an articulated conveyor. The barge conveyor is able to swing left and right, and adjust itself for height and reach to move material into ships anchored at sea at a rate of approximately 1,870 swt per hour.[118] It is the custom aspect of the conveyor system that causes the barges to be several times more expensive than a regular barge of similar capacity.

There are four tugs, and two of them are dedicated to moving the barges. Of the other two, one assists with berthing at the barge berth, and one pulls on the stern of the vessel being loaded to create a lee for the barge. All four tugs are of conventional deep sea design and are rated as follows:

| Iver Foss | 2,200 HP |
|---|---|
| Fairwind | 4,000 HP |
| Stacy Foss | 3,000 HP |
| Sandra Foss | 3,000 HP |

**Methodology**. In the end, the costs generated in this section will be reduced to equivalent annual NED opportunity costs for the purpose of comparing cost without a project against costs with a project. To build a consensus response to this cost comparison, some dissonance among data sources will need to be resolved, and this will require at least three different views on cost to be summarized and reconciled, and they are:

**Teck Cominco Alaska Financial Cost.** This cost is represented by documented contractual financial transactions and is derived from a negotiated rate structure in a very limited market environment. The self-unloading barges, used at Portsite, are custom designed and built for Portsite use and are probably of little use at other ports. Company records indicate cost of the custom self-unloading barges is approximately 5 times greater than the most expensive self-unloading barge shown in Corps' Economic Guidance Memos.

[117] Extracted from actual data for 1999.

[118] Extracted from actual data for 1999.

The agreement that TCAK has with the equipment owner places specific penalties for risk consequences of under performance onto the equipment owner. It also stipulates specific use periods and mobilization allowances while dealing with some of the more standard variable costs. Some of the actual variable costs are handled as a pass through.

This could be described as a partial cost-plus agreement, including a pass through of variable cost with a mobilization allowance, plus an element for capital cost at the site, plus a complicated risk clause. Overall, in any one year results of the agreement will bear only a chance relation to actual incremental financial cost of the equipment, because there are so many unknowns and so many risk issues involved.

The financial cost arrangement is unusual, because it addresses operation in the remote arctic environment and the use of the equipment for open roadstead loading of deep draft bulk carriers during a very short ice-free season. The available company records do not break contract costs into line items for each vessel. The actual TCAK agreement with Foss is not available; however, the cost is estimated at $14,326,000.

**Corps of Engineers Cost Presented in Economics Guidance Memo 00-05 (EGM 05).** This source document, EGM 05, (FY 2000) was the most recent release of official Corps' tug and barge costs, available for use in this analysis. It (EGM 05) stipulates costs for specific sizes and types of tug and barge equipment, based on data gathered for the Mississippi River and associated inland and intracoastal waterways of the United States. Some of the equipment is very similar to the horsepower and size of tugs in use at Portsite. However, when viewed as an indication of costs at remote Alaska locations, there are differences, such as crew costs, which range from about $31 per hour (Corps' data) to records of the Portsite operation showing an average wage of $51.[119] Another difference is in the cost of fuel, which is $.78 for the EGM 05 data (4 year average price '95–'98 includes inland waterways tax), compared to $1.40 for fuel sales at ports in western Alaska.[120] It should be noted that the Portsite fleet does obtain 150,000 gallons of its fuel in Seattle and delivers it to the site during season mobilization. Nevertheless, this economic evaluation is based on opportunity cost, and the opportunity cost of fuel at the Portsite is based on what one has to give up in order to buy it at ports in western Alaska for $1.40. The site value is documented by sales of marine diesel over a multi-year year period with sale reports made once per week at sites in western Alaska. The Corps' sample vessel operating cost data, which is not intended to be representative of the arctic operation at Portsite, is different primarily because of the known difference in the value of labor and fuel.

The $1.40 fuel value is derived from a four year average of northwest Alaska market prices, prior to price spikes related to crude shortages of the Iraq war period, with each year of data updated to a 2003 price level, using national producer price index data for diesel fuel. Implicit in the acceptance of the $1.40 price is the DOE/EIA recognized and applied

[119] Estimated actual range of $38–$63. Average crew cost/hr was estimated from generalized information in a Personal Communication from John Murphy, Transportation Manager, Teck Cominco Alaska to Richard Geiger, U.S. Army Corps of Engineers. See text Table 38 and Table 39 for a summary interpretation.

[120] A database identified as West Coast and Alaska Marine Fuel Prices 1999–2004, Economic Information Fisheries Network, Pacific States Marine Fisheries Commission, 7600 Sandpoint Way NE, Bldg #4, Seattle Washington 98115 accessed at http://www.psmfc.org/efin/data/fuel.html#Data. Average is from '02 and '03.

assumption that short-term price effects related to disruptions in the world supply of crude will be ameliorated with a return to normalization of international trade patterns.[121]

There are some differences in the EGM 05 data format, which vary from the 50-year equivalent annual opportunity cost one ultimately needs in an NED presentation. Specifically the vessel cost part of the analysis does not overtly recognize salvage value nor does it make adjustments necessary to convert the stipulated 20-year capital recover into a 50-year equivalent annual value at appropriate interest rates. These adjustments have a very small impact on the bottom line cost, but they are adjustments which are necessary in order to present a life cycle analysis consistent with NED procedures. Use of data in EGM 05, without adjustments for custom equipment cost, or locality adjustments for labor and fuel cost, and ignoring salvage value, and economic life issues, results in an season fleet cost of $2,852,300.

**Dedicated Fleet Season Cost Using EGM 05 Unadjusted**

| Equipment | Annual Cost ($) |
|---|---|
| 2,200 HP | 517,800 |
| 3,000 HP | 630,600 |
| 3,000 HP | 630,600 |
| 4,000 HP | 776,200 |
| 2 Barges | 297,100 |
| EGM 05 Unadjusted Fleet Cost | 2,852,300 |

Labor and fuel make up about 33% and 25% of the hourly cost of tugs, based on the layout of EGM 05. If one makes only the adjustments for labor and fuel ($31/hr in EGM 05 vs. $51/hr at Portsite, and a fuel cost differential of $.78 in EGM 05 vs.$1.40 at the Portsite) the cost of four tugs becomes $5,079,700. To this one needs to add the cost of fuel, equipment, and crew that was left out of the self-unloader barge cost of EGM 05, and the result is $6,001,600.

**Table 35. Dedicated Fleet Season Cost EGM 05 Adjusted**

| Adjustment | Annual Cost ($) |
|---|---|
| EGM 05 Unadjusted Fleet Cost | 2,852,300 |
| Tug Labor Cost Adjustment | 1,378,200 |
| Tug Fuel Cost Adjustment | 1,148,500 |
| Barge Crew Adjustment | 299,200 |
| Barge Fel Adjustment | 323,400 |
| EGM 05 Adjusted Fleet Cost | 6,001,600 |

**Cost Estimated Using EP 1110-1-8 (EP).** The Corps of Engineers engineering pamphlet EP 1110-1-8, presents a format for establishing cost of construction equipment including marine equipment. The EP is intended for use in arriving at the cost of solicitations and construction, and in that sense, is intended to be a substitute for market values when actual cost is unknown. The methodology applies a complex algorithm that incorporates locality specific data with numerous other adjustments not explicit in the cost analysis of EGM 05.

[121] *Annual Energy Outlook With Projections To 2025*, EIA/DOE Report #: DOE/EIA-0383(2004) Release Date: January 2004, Accessed At http://www.eia.doe.gov/oiaf/aeo.

The manual includes appendix data for use in localizing the cost estimate to account for regional variance, and all of Alaska is treated as a contiguous region. The procedure allows for adjustments to such items as fuel cost, consumption rates, salvage value, interest rate, original cost, and other variables that are used as input to a format for estimating the cost of a particular type of equipment. Tugs are one equipment class, and within the class are horsepower categories matching the fleet in use at the Portsite.

The procedure in EP is generally consistent with the idea that NED economics must evaluate resources based on opportunity cost. The procedure in the EP accounts for economic adjustments, such as initial cost, present value, salvage value, and economic life of the equipment, and reduces all of the costs to an hourly or monthly equivalent. Since NED project evaluation generally adopts a 50-year planning period, there is a small discrepancy between hourly costs extrapolated to annual values and annual values arrived at using life cycle costing for all elements required over the 50-year period.

**Selected Procedure**. The analysis of operating cost cannot reasonable be based strictly on the Corps' Economics Guidance Memos, because the differences between the Mississippi River equipment, typified in the vessel inventory and Mississippi River working conditions, and those in the arctic are considerable. Nor can it be based entirely on the financial data from TCAK, because the company data is in a format different from that used in Corps' sources, and it does not necessarily represent reconstructed cost. The derivation of reconstructed costs, therefore, depends somewhat on TECK data as a guide to unit values, and the Corps' EGM format as a reporting basis.

The application in this report was refined during the Independent Technical Review (ITR). ITR judgment prevailed over specific TCAK data and Corps' data where the three did not align. Reliance on the cost estimating structure of EP was set aside in the interest of line-by-line itemization.

Operating hours used to determine hourly equivalent costs are from TCAK records of prior seasons. The records support adjustments that recognize the vessels will be in operation 75% of the time that they are onsite. Crew labor costs are calculated, based on actual at-site labor costs, and crew hours are based on the crew being present at all times when the vessel is onsite.

Vessel capital costs are adjusted to life-cycle equivalents. This is necessary to accommodate salvage value involved in replacing the vessels. Replacement is necessary to allow adequate capital to provide vessel service over the 50-year economic life of the project.

**Table 36. Life Cycle Cost Adjustment Dedicated Fleet Tug and Barge Operation Non-Labor Cost**

| | 2,200 HP | 3,000 HP | 4,000 HP | Barges |
|---|---|---|---|---|
| Cost[122] | $2,500,000 | $3,500,000 | $4,500,000 | $15,700,000 |
| Life[123] | 25 | 25 | 25 | 25 |
| Salvage[124] | $855,000 | $1,200,000 | $1,539,000 | $145,000 |
| Net PW cost of replacement | $444,400 | $621,300 | $799,800 | $4,201,800 |
| Net PW | $2,944,400 | $4,121,300 | $5,299,800 | $19,901,800 |
| 50-Year A&I[125] | $170,700 | $239,000 | $307,300 | $1,153,900 |
| Annual Hrs[126] | 2,150 | 2,150 | 2,150 | 2,150 |
| Ownership/Hr | $79 | $111 | $143 | $537 |
| Summary | | | | |
| Non-labor Hourly Cost[127] | $325 | $409 | $508 | $825 |
| Hourly Labor | $229 | $229 | $229 | $181 |
| Total Hourly Cost | $554 | $638 | $737 | $1,006 |

**Table 37. Labor Cost[128] Tug Crew**

| | Tug Master | 1 Mate/1 Engineer (2 X Amount) | 2 Tug Crewmen (2 X Amount) | Crew Total |
|---|---|---|---|---|
| Basic | $26.88 | $19.70 | $13.24 | $92.76 |
| Vac Hr | 10.6 | 7.77 | 5.52 | 37.18 |
| Worker Comp | 8.62 | 8.62 | 8.62 | 43.10 |
| Tax/Ins | 3.21 | 2.35 | 1.58 | 11.07 |
| Subtotal | 49.31 | 38.44 | 28.96 | 184.11 |
| Fringe | 8.97 | 8.97 | 8.97 | 44.60 |
| Hourly | 58.28 | 47.41 | 37.93 | 228.71 |
| Hours[129] | 2690 | 2690 | 2690 | |
| Total | $156,800 | $127,500 | $102,000 | $615,800 |

[122] Cost of tugs is based on comparable sales. Data was provided by Marcon International. Cost of the self-unloading barge is based on original cost plus a statement from the builder regarding cost to build an additional unit in year 2001 and verified as still applicable for use in 2003.

[123] Established by marine survey of Foss tugs in connection with contract arrangements.

[124] Based on tugs on the market in 2001 with an age of 30 years reduced to cost per horsepower. Salvage value of the barge is arrived at by establishing a scrap value of $145/ton for hulls.

[125] 50-years at 5 3/8%.

[126] 2150 operating hours is estimated from actual operating time at Portsite and adjusted down by 25% to account for hours in use plus an allowance of 530 hours of mob and demob time.

[127] Non-labor cost include fuel for the primary and secondary engine, lube, service, filters, repair parts and supplies all derived from appendix data in EP1110-1-8. Other operating costs are estimated based on actual cost.

[128] Overtime 29.52%, holiday 1.92%, vacation 8%, Social Security 7.65%, state Unemployment 3.5%, Federal unemployment .8%.

[129] Labor hours exceed vessel operating hours due to idle time requiring presence of crew. Hours are mob and demob 530, July 576, August 744, September 720, and October 120. Operating hrs are 2,160.

**Table 38. Labor Cost[130] Dedicated Barge Crew**

| | 1 Barge Supervisor | 2 Fel Operators (2 X Amount) | Crew Total |
|---|---|---|---|
| Basic | $30.33 | $27.08 | $84.49 |
| Vac Hr | 11.96 | 10.68 | |
| Worker Comp | 8.62 | 8.62 | 25.86 |
| Tax/Ins | 3.62 | 3.24 | 10.10 |
| Subtotal | 54.53 | 49.62 | 153.77 |
| Fringe | 8.97 | 8.97 | 26.91 |
| Hourly | 63.50 | 58.59 | 180.68 |
| Hours | 2496 | 2496 | |
| Total | $158,500 | $146,200 | $450,900 |

**Table 39. Annualized Life Cycle Cost Dedicated Tug And Barge Operation Labor and Non-Labor Cost Included**

| | 2200 HP ($) | 3000 HP ($) | 4000 HP ($) | Barges ($) |
|---|---|---|---|---|
| Investment | 170,700 | 239,000 | 307,300 | 1,153,900 |
| Operation&Repair[131] | 345,600 | 447,100 | 583,200 | 367,500 |
| Labor[132] | 615,800 | 615,800 | 615,800 | 450,900 |
| Transportation | 15,400 | 15,400 | 15,400 | 9,200 |
| Management | 62,400 | 62,400 | 62,400 | 37,400 |
| Insurance | 24,500 | 34,300 | 44,100 | 155,900 |
| Deck Supplies[133] | 18,700 | 18,700 | 18,700 | 0 |
| Tow Wires | 4,200 | 4,200 | 4,200 | 0 |
| Commissary[134] | 6,700 | 6,700 | 6,700 | 2,600 |
| Training&Support[135] | 6,200 | 6,200 | 6,200 | 3,700 |
| On-Site Supervisor | 15,800 | 15,800 | 15,800 | 15,800 |
| Winter Storage[136] | 10,700 | 10,700 | 10,700 | 10,700 |
| Uninsured Casualty | 17,900 | 17,900 | 17,900 | 17,900 |
| Total Annual | 1,314,600 | 1,494;200 | 1,708,400 | 2,225,500 |

**Other System Direct Costs.** The tug and barge operation is a distant water fleet, requiring home office support in the form of administration of business activities for the 26 crew persons plus onsite supervisors. Corps' data for other tug and barge operations indicates 11%–13% home office administrative cost is normal. The cost needs to be added to the at-site (non-capital) reconstructed cost $7,202,200, to provide offsite resources necessary to make the operation workable in the reconstruction. Administration cost at 12% (IWR standard) is therefore $864,300.

[130] Barges are onsite an average of 104 days per season.

[131] Calculated using EP 1110-1-8.

[132] Labor rates, transportation, management, and insurance cost were checked with Teck Cominco Alaska cost reports and reconciled with regional data sources by POA cost Engineering Section in 2001. Estimates were verified as reasonable when confidential cost data was viewed for 2002 and 2003 operations.

[133] Hawsers, line, safety gear, survival equipment, tools.

[134] Vessel stores allocated by 24 hr crew numbers.

[135] Cost allocated per crew. Includes on-site and off-site training for safety; plus technical aspects of license maintenance and upgrade, vessel systems qualification, drills, and inspections.

[136] Storage and insurance were estimated and allocated by vessel.

Identification of profit is presented as a category of other direct system cost instead of being bundled with line item costs. This approach is consistent with NED principles as described in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) of March 1983.* That document states NED costs are "...the national economic opportunity costs of resource use." In order to attract the Foss equipment away from use at Portsite, one would have to pay an amount, at least equal to the contract (including profit, incentives, etc.), plus any penalties Foss would incur by terminating the service prior to fulfillment of the contract. Profit qualifies as a system cost, because it is a form of risk compensation determined by market forces. It belongs in the analysis as a relevant cost because, when the with-project condition is implemented, the tug/barge loading operation goes away, and with it, profit stipulated at 10% amounting to $1,132,700.

**Table 40. Dedicated Fleet Annual Cost**

| Equipment | Annual Cost ($) |
|---|---|
| 2200 HP | 1,314,600 |
| 3000 HP | 1,494,200 |
| 3000 HP | 1,494,200 |
| 4000 HP | 1,708,400 |
| Barges | 4,451,000 |
| Fleet Cost At Site | 10,462,400 |
| Fleet Administration[137] | 864,300 |
| Fleet Profit[138] | 1,132,700 |
| R | 1 |

**Comparison With Other Owners Estimates.** The tug equipment now in service at Portsite is not new, and it is not unique, in the sense that it is similar to other equipment used regularly by Northland Services, Foss Maritime, and Crowley Marine at other Alaska locations. In interviews conducted for the purpose of documenting the cost of similar equipment of similar size and design in direct and indirect use at 27 Alaska locations north of the Aleutian Chain, officials of Crowley Marine, Northland Services, and Foss Maritime in 1998 concurred in estimated daily costs from events that result in taking a tug and a standard barge out of service ranging from $12,000 to $14,000.[139] This would equate to an opportunity cost of $1,344,000 and $1,568,000 for 112 days of use related to the Portsite operation, in 1998 prices.

In 1998, marine fuel costs at Bering Sea locations were about $1.00 gal for purchases of 600 gallons, and as of 2002, had increased by almost 40%.[140] On average for the comparison fleet, fuel makes up about 31% of the annual cost. The other 69% of the cost was updated, using the producer price index for the building of ships and boats, a 13% increase from 1998

[137] ITR recommended 12% consistent with IWR data.

[138] Derived from ITR input, Gulf Engineers.

[139] Personal communications with Barry Hackler, Northland Services, Leonard Campbell of Ocean Mogul Towing under contract to Northland, Don Stultz Crowley Nome port manager.

[140] West Coast and Alaska Marine Fuel Prices 1999–2001, Economic fisheries Information Network, Pacific States Marine fisheries Commission.

to 2003. Weighting yields an overall price update factor of 1.22 indicating the season opportunity cost above would be about $1,639,700 and $1,913,000 respectively in nominal 2003 dollars.

The above cost is not comparable to the cost of a tug at Portsite, because it was originally estimated as the cost of a tug and standard barge together. The cost of the barge can be subtracted out of the total by taking out 21%,[141] indicating that a season equivalent cost for the tugs would range from $1,295,400 to $1,511,200 in nominal 2003 dollars. This compares favorably with the reconstructed tug cost range of $1,314,600 to $1,708,400.

Up-to-date day rates for anchor handling tugs are reported to range from $10,137 to $17,380, depending on horsepower.[142] At these rates, 112 days of use would cost from $1,135,300 to $1,946,600.

**Risk Circumstances**. The TCAK arrangement with Crowley was discussed in connection with preparation of this report; however, details of the information are proprietary and disclosure problems are present. It is appropriate to state that annual financial cost of all of the tug and barge related equipment is well in excess of the reconstructed $12,459,400 shown in table 41, and probably quite close to $14,326,000. The contract arrangement includes risk compensation clauses that cause the contract cost to exceed reconstructed costs.

It is recognized that there are unusual risks involved in the shipping arrangement, and some of these would include:

- Extreme aspects of the distant arctic environment.
- Lack of alternative ports.
- Lack of alternative modes.
- Lack of appropriate equipment that can be speedily adapted to mitigate equipment failures in the course of a season.
- Lack of other shipping choices.
- Limitations of a short ice-free season.
- Lack of back-up equipment.
- Effects of storm interruptions.
- Hazards of open roadstead loading.

The risk issue has not been quantified in the benefit-cost analysis; however, it is believed that the risk consequences could be severe, and alleviation of risk could have value.

A series of storms in any year could cause damages, putting both barges out of service and shutting down the world's most productive zinc mine. However, there is no way to reliably estimate the forces of storm generated sea conditions acting on the barges or the probability

[141] Personal communication from Barry Hackler, Northland Services to Ken Boire during preparation of the Nome Navigation feasibility report.

[142] Work Boat Magazine, February 2005, page 12, cost range for over 6,000 HP and under 6,000 HP. Day rates are shown to fluctuate up to 56% from year to year.

that such storm events happening either singly or in series while a barge is under tow. It is also unworkable to precisely predict the event damages, although it is clear that they could be huge. For example, a loss of both barges in route to Portsite (barges are stored for the winter in Puget Sound and must transit the Gulf of Alaska and the Bering Sea) could lead to NED net income losses of $200,000,000–$300,000,000 in a single year. It is known that companies world-wide have set a norm of charging more for operating in risky situations;[143] however, there has been no benefit included for reduction of this risk by alternative plans that would take the tug/barge operation out of service as part of the with-project condition.

**With-Project Condition**. The with-project condition substitutes an extended conveyor loading system and two tractor tugs (up to 4,000 HP each) for the tug and barge lightering system. The equipment, which will no longer be needed in the with-project condition, will have a salvage value, but the salvage value has already been netted out of the without-project cost. One of the contract terms between Foss and TCAK is that, in the event that services of Foss are terminated, there is a one-time severance charge that declines each year becoming zero in 2009. Since 2011 will be the first year of the project life, there is no need to treat this as an associated cost.

**Annual Benefit**. The annual cost $12,459,400 must be adjusted to reflect that the mine is estimated to have a 40 year life as of 2002. The benefit stream will not start until 2011 leaving benefits to be earned over 31 years of the 50-year project economic life. Using a 5 3/8 % discount rate, the annual benefit has an accumulated present worth of $186,067,300 and an annualized 50-year NED benefit value of **$10,788,300**.

The above benefit estimate is subject to uncertainties in the cost estimating methodology that it is based on; however, the procedures used to make the estimates are standardized and uniformly applied. The basic data that the estimates are based on is from primary sources specific to the project locality and is also considered to be reliable.

**Associated Cost of the With-Project Condition**. The financial cost of the with-project condition includes two tractor tugs needed to manage deep draft vessels calling at the terminal, and this amounts to $3,736,800 annually (see table 85), including an allowance for the capital cost, labor, consumables, administrative overheads, and profit. For purposes of economic analysis, these cost are identified as associated costs. As such they are costs that need to be incurred to realize the project benefits, even though they are not an actual part of the project. Including them in the analysis helps to account for all of the resources required to earn the benefit stream.

[143] "In case of ice problems, a surcharge of 10-30% of the ...the hourly rate is charged." Port of Sundsvalls, Box 805, S-851 23 SUNDSVALL, Besöksadress: Tunadalshamnen, Sweden; and "Services provided to vessels without main engine power and/or without steering will be subject to a surcharge of 50% of the applicable rate." Adsteam Medway, Garrison Road, Sheerness Docks, Sheerness, Kent ME12 1RS; and "...when company tugs are employed in hazardous or dangerous tug work ... a 50% surcharge will be added to the applicable rates unless negotiated other wise as a mutually agreeable rate." Hawaiian Tug and Barge, P.O. Box 3288, Honolulu Hawaii 96801. Also "...When assisting vessels disabled, stranded or in distress, the rates to be charged will be 50% higher than the applicable hourly rate.", Sause Bros Inc, 155 E. Market Ave, Coos Bay, OR 97420.

# 6.0 NED VALUE OF INDUCED TONNAGE

**Purpose**. The purpose of this section of the report is to present an analysis of the NED benefit of tonnage induced by the proposed DMT improvements. The basic proposition is that shipping constraints constitute a bottleneck on the number of tons which can be shipped in a season; the bottleneck will be opened up with the proposed navigation improvements. The bottleneck is a result of the existing lightering system, which is limited by a design throughput rate. The design throughput capacity is subject to being shut down by adverse weather conditions not uncommon in the arctic environment especially where open roadstead loading is a requirement. The existing Portsite system has an absolute physical limit; it is not possible to ship the commodity by an alternative mode or through an alternative port, because neither one is present at the location.

In addition to making it possible to ship more tons, the proposed improvements will introduce other efficiencies that cause shipping costs to be lower as well. In this report the benefit realized for tons shipped in the without-project condition are explained separately from the benefit of induced tons.

**Basis for Measurement, the With- and Without-Condition.** This part of the report quantifies the economic gains from induced tons of zinc concentrate. The gain (NED benefit) is derived from simulations of production cost under conditions with the project and without it. The analysis is directed toward demonstrating the NED value of each induced ton by measuring it in terms of the amount and value of goods that the induced tons add in the market place. This project related increase in goods produced has a NED economic value because, without the proposed project, the flow of goods will be at a lesser level, with lower total value to the nation. NED economics measures the value of goods and services produced with a project, compared to without a project, based on a theoretical willingness to pay (WTP). Essentially this is the end user's WTP for the delivery of the commodity, based on an expectation of the net income that it can provide. The benefit calculation, therefore, discusses three essential themes: production cost, commodity value, and transportation cost.

The Principles and Guidelines address the subject of induced tonnage for navigation projects as follows. "If a commodity or additional quantities of a commodity are produced and consumed as the result of lowered transportation costs, the benefit is the value of the delivered commodity less production and transportation costs. <u>More precisely, the benefit of each increment of induced production and consumption is the difference between the cost of transportation via the proposed improvement and the maximum cost the shipper would be willing to pay</u> (emphasis added). Where data are available, estimate benefits for various levels of induced movement. In the absence of such data, the expected average transportation cost that could be borne by the induced traffic may be assumed to be half way between the highest and lowest costs at which any part of the induced traffic would move."

This is interpreted to mean that a measure of theoretical WTP is the basis for quantifying the amount of the NED benefit. Willingness to pay is limited by the amount of net income that a good or service provides, or the cost of alternatives to it. The reason why WTP is limited to the amount of net income is that paying an amount greater than net income would create an overall loss situation which would be an irrational act. Similarly, if there is an available alternative source or substitute commodity, one would not pay more than the cost of the alternative source or the substitute good for the same reason. Willingness to pay an amount less than net income would be an attractive choice but does not indicate the maximum value that one would be willing to pay for the service of getting additional tons of concentrate to market, because it understates the market value of the resource and willingness to pay for it.

In this report WTP has two major controls, net income and alternative cost, and two frames of reference, the supplier and the end user. The rationale behind the WTP concept as a measure of economic value of a good or service is that a party is theoretically better off up to the limit of experiencing a net income gain. In that respect one is willing to pay for goods and services up to the limit of net income that the good or service can provide.

From the standpoint of the producer, where shipment of zinc concentrate is the good, the producer would theoretically be willing to pay an amount up to a limit of the incremental net income an additional unit of production would provide. In the case of Red Dog Mine, the net income per lb of concentrate is about $.09, at a production level of 1,544,000 swt annually, and a finished zinc market price of $.53 lb. Finished prices and current production costs are used (BASE CASE simulation). Red Dog concentrate yields about 50–55 lbs of zinc for every 100 lbs shipped so that 1,544,000 swt of concentrate produces about 849,000 tons of zinc with a profit per lb of zinc at $.18.

With the proposed improvement, resulting in a small quantity increase being brought into the market, a shift in the supply curve takes place. Therefore, there is theoretically one supply curve for the without-project condition and one for the with-project condition. The incremental concentrate quantities in this report amount to less than 1% of the total world supply, and effects of the newly introduced commodity are so small that they essentially disappear within the short-term fluctuations of the world market for zinc concentrate. The concept of a supply shift is valid, but it is a theoretical construct which is too small to either quantify or to have a material impact on the results of the overall WTP analysis, and therefore, it is set aside for the rest of this discussion.

**Substitute Sources**. The nature of the industry supply function is revealed by the World Mine Cost Data Exchange Model[144] used in this report. It is a cost model which has been applied to demonstrate the industry-wide cost of various sources of supply. It is also used in this report to explore the relation between cost and various levels of output at Red Dog. The industry supply function, including Red Dog Mine, is shown in the table below:

[144] Available at www.http.Minecost.com

**Table 41. World Mines In 2003**

| Mine | Production (zn kt) | Operator | Cost (Zn c/lb) |
|---|---|---|---|
| El Porvenir | 93.1 | Milpo | 19.3 |
| Rosebery | 82.9 | Pasminco | 21.4 |
| Boliden Area | 76.9 | Boliden | 21.6 |
| Iscaycruz | 137.0 | Glencore | 22.7 |
| Raura | 21.7 | Raura | 23.4 |
| Skorpion | 47.4 | Anglo American | 25.4 |
| La Cienega | 9.4 | Penoles | 25.7 |
| Louvicourt | 17.7 | AUR/Teck/Novicourt | 26.1 |
| Rampura Agucha | 242.4 | HZL | 26.8 |
| Atacocha | 60.0 | Atacocha | 27.1 |
| Pering | 4.3 | BHP-Billiton | 27.2 |
| Antamina | 270.0 | Teck-Cominco/BHP-Billiton | 27.4 |
| Cayeli | 33.6 | Inmet | 28.1 |
| Zinkgruvan | 65.7 | Rio Tinto | 28.2 |
| Yauli | 97.9 | Volcan | 28.7 |
| San Vicente | 32.5 | SIMMSA | 28.9 |
| Charcas | 64.3 | Grupo Mexico | 28.9 |
| Century | 511.5 | Pasminco | 29.2 |
| El Mochito | 43.8 | Breakwater Res | 29.2 |
| Huanzala | 43.3 | Santa Luisa | 29.2 |
| Cannington | 60.5 | BHP-Billiton | 29.4 |
| Golden Grove-Scuddles | 54.6 | Newmont | 29.7 |
| Quiruvilca | 12.5 | Pan American Silver | 29.8 |
| Matagami/Bell Allard | 109.7 | Noranda | 30.0 |
| Lennard Shelf | 137.5 | Western Metals | 30.3 |
| Red Dog | 579. 3 | Teck-Cominco | 30. 5 |
| Bougrine | 35.0 | Breakwater Res | 30.9 |
| Naica | 34.9 | Penoles | 31.1 |
| Gordonsville | 35.6 | Pasminco | 31.6 |
| Sabinas | 27.2 | Penoles | 32.1 |
| Broken Hill | 170.4 | Perilya Mines | 32.2 |
| La Ronde | 45.5 | Agnico Eagle | 32.5 |
| Tizapa | 19.6 | Penoles | 32.7 |
| Sweetwater | 2.0 | Doe Run | 32.7 |
| Colquijirca | 58.5 | El Brocal | 32.8 |
| Fresnillo | 13.0 | Penoles | 32.8 |
| Garpenberg | 44.3 | Boliden | 33.0 |
| Greens Creek | 69.6 | Rio Tinto/Hecla | 33.8 |
| Doe Run | 33.0 | Doe Run | 33.9 |
| Brunswick | 286.5 | Noranda | 34.1 |
| El Monte/Zamipan | 3.7 | Penoles | 34.1 |
| Huaron | 18.9 | Pan American Silver | 34.6 |
| St. Barbara | 32.5 | Grupo Mexico | 34.9 |
| Cerro de Pasco | 121.1 | Volcan | 34.9 |
| Rosh Pinah | 49.3 | Kumba Resources | 35.0 |
| Montana Tunnels | 9.9 | Apollo Gold | 35.2 |
| Elura | 73.0 | Pasminco | 35.2 |
| Bouchard-Hebert | 53.8 | Breakwater Res | 35.2 |
| Francisco Madero | 82.3 | Penoles | 35.7 |
| Galmoy | 72.0 | Arcon Resources | 35.7 |

| | | | |
|---|---|---|---|
| Lisheen | 169.3 | Anglo American | 35.7 |
| San Martin | 23.0 | Grupo Mexico | 35.8 |
| El Toqui | 32.8 | Breakwater Res | 36.0 |
| Bismark | 45.1 | Penoles | 36.0 |
| Myra Falls | 57.4 | Boliden | 36.5 |
| Reocin | 17.5 | Xstrata | 37.2 |
| Tara | 188.4 | Outokumpu | 37.3 |
| Lucky Friday | 2.5 | Hecla | 37.5 |
| Black Mountain | 25.9 | Anglo American | 38.8 |
| Mt Isa/Geo Fisher | 169.4 | Xstrata | 39.1 |
| Kidd Creek | 75.5 | Falconbridge | 39.3 |
| Zawar Mines | 32.5 | HZL | 39.4 |
| Mt Garnet | 18.9 | Kagara Zinc | 39.4 |
| McArthur River | 173.3 | Xstrata | 39.6 |
| Rajpura Dariba | 28.5 | HZL | 40.4 |
| Les Mines Selbaie | 25.0 | BHP-Billiton | 40.5 |

In the models used to generate the above costs, all onsite mine costs are allocated across the main metals and co-product metals in proportion to their net smelter return to the mine operator. Offsite costs are charged to each relevant mine product. Mine byproducts are credited against the cost of production of the co-products. Prices used in the models were generally those prevailing in 2003: Zn $.47/lb, Pb $38/lb, Cu $1.23/lb, Ag $6.20/oz, Au $395/oz.

The above model run is for year 2003 production levels with costs in constant 2003 dollars. Runs for other years change the appearance of particular mines in the array, as new mines enter and others are exhausted, while ore quality of others declines. There are also structural mine modifications and ore quality variations which change the operating cost of existing mines. For example the cost per lb of Red Dog zinc over 1998–2002 was $.378, $.376, $.397, $.365, and $.333, respectively. Typically, operating costs of a given mine will change from year to year. The structural aspects of the overall industry cost curve of any one year, however, is generally typical of all years, although the curve may shift a bit as new mines enter and old ones close. In 2003 the curve flattened significantly over 2001, due to new mine development, adding low cost sources and high cost mines being shut down. It is anticipated to shift again with some lower cost mines entering production around 2004–05.

Year 2003 was selected to demonstrate the supply curve, because it shows an up to date list of suppliers as this report is being prepared. It can be regarded as a typical year for suppliers, although not necessarily a typical year for prices. A chart display of the industry cost data for year 2003 is shown in figure 2.

It is not possible to obtain useful data on all of the world's zinc mines because of disclosure problems, international political barriers, data conventions, basic record keeping issues, and so on. As a result, the above cost curve represents 81% of the western world zinc mines operating in 2003 while accounting for 5,386,100 tons of the over 6 million tons produced in the western world. On a world-wide basis, the cost curve represents a 63% sample of all production, which was about 8.5 million tons in 2003. The curve is built from mines for which acceptable data is available, and the main exclusions are India and restricted coverage of some Mexican companies. The 19% of western world mine output, not represented in the above operations, is distributed through the 63% sample; therefore, the curve, which results from the sample, is treated as being representative of the industry.

**Red Dog Production Cost.** The cost of Red Dog, at various production levels, was estimated using a mine cost model with input data gleaned from historic operations at Red Dog from data on typical or average industry unit costs where specific site data was not available. Like costs for the industry overall, the costs for any one mine will vary from year to year because of changes in mine operation, ore content, capital investments, and so on. In the interest of isolating these extraneous issues, the cost of Red Dog at various production levels was estimated for only the selected "typical year," 2003. A Red Dog production function was developed for this one year to demonstrate the model application. A summary of some of the more important model inputs is presented in the following table, and a table summary of the cost results follows after that:

## Table 42. Red Dog Mine/Mine Cost Model Summary Of Flowsheet and Technical Inputs

| Cost Inputs | 2003 |
|---|---|
| Average Hourly Labor Cost Including Burden ($/hr) | 36.32 |
| Power Cost (c/kWh) | 8.9 |
| Diesel Cost (c/liter) | 50.1 |
| Grinding Media ($/t) | 900 |
| | |
| Mine Production Data | |
| Daily Mining Rate (ore + waste) | 17,917 |
| Operating Days/Year | 360 |
| | |
| Mill Production Data | |
| Daily Milling Rate | 8,641 |
| Operating Days/Year | 365 |
| Metric Tons Material Hauled/day | 3,440 |
| Long Distance Truck Haul km | 83 |
| | |
| Production Rates | |
| OP kt Ore Mined/Manyear | 29 |
| OP kt Material Moved/Manyear | 59 |
| Mill ktTtreated/Manyear | 35 |
| Total Mine & Mill kt Treated/manyear | 9 |
| | |
| Ore Reduction | |
| OP Powder Factor kg/t material moved | 0.22 |
| UG Powder Factor kg/t material moved | 0.00 |
| Crush & Grind Media kg per t milled | 7.3 |
| Reagents $/t ore milled | 2.06 |
| | |
| Fuel Productivity | |
| OP diesel fuel litres/t Ore Mined | 3.1 |
| OP diesel fuel litres/t Material Moved | 1.5 |
| Mill oil fuel litres/t Ore Milled | 0.3 |
| Concentrate Drying Fuel Oil/t Ore Milled | 0.0 |
| Mine & Mill litres diesel fuel/Ore Treated | 3.4 |
| | |
| Electricity Productivity | |
| OP kWh/t Ore Mined | 5.4 |
| OP kWh/t Ore Material Moved | 2.6 |
| UG kWh/t Ore Mined | 0.0 |
| Comminution kWh/t Ore Milled | 48.7 |
| Ore Treatment kWh/t Treated | 15.8 |
| Mine & Mill kWh/t Ore Treated | 70.0 |

**Table 43. Red Dog Mine Daily Cost, Summary Of Mine Cost Model, Output Year 2003**

| Item | Daily Cost ($) |
|---|---|
| Mine | |
| Drill & Blast Ore & Waste | 7,910 |
| Excavate, Load & Haul Waste | 27,422 |
| Excavate, Load & Haul Ore | 26,562 |
| Mobile Crushing | 0 |
| Ore Transport to Mill | 2,281 |
| Stockpile Store & Reclaim | 4,458 |
| Mine Services | 7,155 |
| Mine Administration | 10,374 |
| Mine Camp | 40,955 |
| Total Mine | 127,116 |
| | |
| Mill | |
| Crushing | 2,039 |
| Grinding | 113,244 |
| Flotation | 24,434 |
| Concentrate Thicken & Filtration | 10,501 |
| Tailings Disposal | 1,366 |
| Mill Services | 16,146 |
| Mill Administration | 21,350 |
| Stockpiles Store, Reclaim & Ship | 4,136 |
| Total Mill | 193,217 |
| **Onsite Mine and Mill Cost** | **320,332** |
| Shipping | 244,359 |
| Treating and Refining | 527,240 |
| NANA Royalty | 24,914 |
| Total Daily Cost | 1,116,846 |

**Table 44. Red Dog Mine: Reconciliation**

| Reconcilliation | Units | Amount |
|---|---|---|
| Total Cost per Day | $/d | 1,116,846 |
| Operating Days per Year | d | 365 |
| Total Cost per Year | $m | 407.65 |
| Annual Credits Paid | $m | 30.04 |
| Less Offsite Cost on Credited products (already included in Total Cost) | $m | 46.08 |
| Net Annual Cost | $m | 331.53 |
| Annual Ore Milled | kt | 3,154 |
| Annual Cost per mt Ore Milled | $/t | 129.25 |
| Annual Credits per mt Ore | $/t | 9.52 |
| Less Offsite Cost on Credited products (already included in Total Cost)/t ore milled | $/t | 14.61 |
| Cost After Credits per mt Ore | $/t | 105.11 |
| Annual Paid Pb Production | kt | 118.33 |
| Annual Paid Zn Production | kt | 492.41 |
| Annual Paid Ag Production | t | 96.85 |
| Paid Pb Cost after Credits | $/lb | 0.00 |
| Paid Zn Cost after Credits | $/lb | 0.31 |
| Paid Ag Cost after Credits | $/oz | 0.00 |
| Net Cost Pb Production | $m | 0.00 |
| Net Cost Zn Production | $m | 331.53 |
| Net Cost Ag Production | $m | 0.00 |
| Net Annual Cost | $m | 331.53 |
| Net Annual Cost per mt Ore | $/t | 105.11 |

Using the above approach, the cost of Red Dog production was estimated for projected concentrate production levels of 1,544,000 short tons before year 2011, and for post–2011 production levels of 1,352,000, 1,544,000, and 1,729,000 short tons. For the cases judged to be "most likely," these output levels yielded cost per lb of finished metal at $.305,$.328,$.323, and $.365 respectively. The unit cost will vary, depending on the assumptions, input to the model. The above costs reflect assumptions, as consistent as possible, with the current operation with two exceptions:

- An ore quality change is postulated for post–2011 production, with prices kept constant at 2003 prices.
- Lower ore quality for post–2011 was accompanied by higher mining rates and lower production efficiency.

These points were used to estimate the cost of upper range output levels, while the unit cost for the production range below them was tied to historical costs.

For the lower end of the curve, specific years were selected from mine operation between 1992 and 2003, and were adjusted to 2003 price levels using the producer price index for durable goods manufacturing. The United States producer price index for zinc concentrate is too distorted by the presence of Red Dog, which makes up most of the U.S. production. From 1992–2003, historical mine output spanned a range of concentrate produced from 453,000 tons in 1992 to 1,381,000 tons in 2003 and a cost per lb of finished metal ranging from $.31 to $.54.

Cost data for 1998 and later is more representative of the present day mine production function, because 1998 was the first year that present day production improvements were in place, which had the effect of reducing operating costs substantially. The production cost of 1998 was $.37/lb. The following chart demonstrates the relationship between cost and output with output shown as tons of concentrate and cost shown per lb of finished zinc.

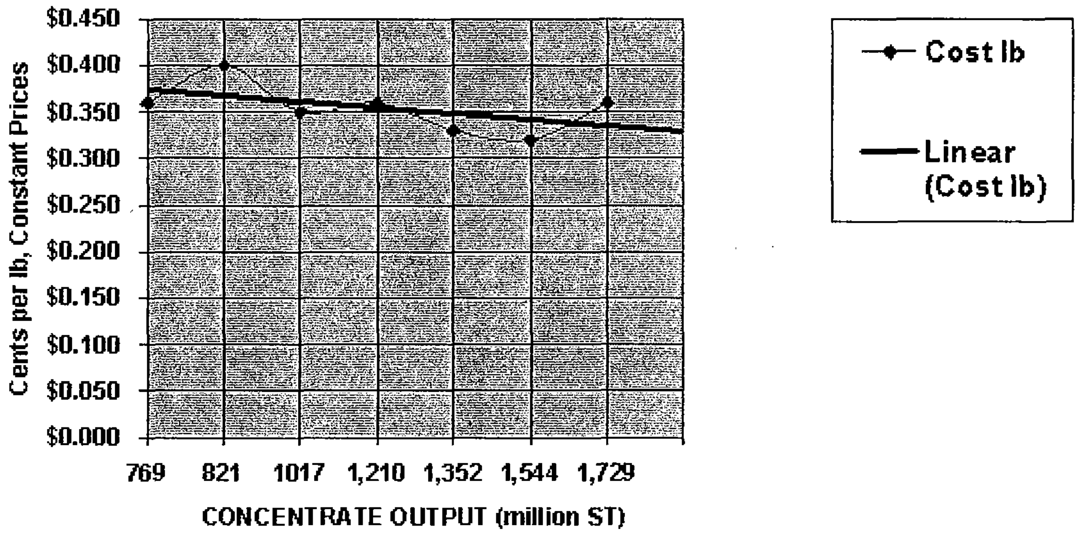


Figure 5. Red Dog Mine Unit Cost

**Relation of Zinc Price and Willingness-to-Pay (WTP).** Between 1995 and 2000, western world zinc mine production increased by 18%, a significantly greater rise than the 12% expansion in western world zinc demand seen during the same period. It would seem logical to conclude that zinc mine production has been able to offer the prospect of attractive profit margins; however, this has not been the case for all operators because of the relatively wide spread in cost among the various suppliers.

In 1995 the western world refined zinc market was in a large deficit. The market swung into a surplus with low prices five years later, and today, it is swinging back to a deficit situation with a drawing down of inventories as demand grows and prices climb back toward the 1995–2000 average of $1,100/t ($.55 lb).

Given the poor financial performance of upper quartile mines in the last couple of years because of low prices and/or high production costs, projects seeking financing today must be able to demonstrate that they can earn a reasonable return, assuming lower prices than were used to justify the previous generation of new mines. Although prices are expected to bracket a long-run average of $.53 lb, investors, evaluating investments in zinc mines today, examine whether or not expectations of an average zinc price of no more than $1,000/t ($.50 lb) or even lower, will bring satisfactory rewards to investments in new mine capacity.

There are many zinc mine projects, including expansions of existing capacity, in the pipeline. However, it is far from clear which projects will be developed for there are environmental, permitting, and/or infrastructure issues to be resolved as well as cost and profitability issues. Some of the potential new projects appear to offer sound economic returns when tested against prices of under $.50. It is against this world wide price cycle and profit squeeze that Red Dog continues to perform as one of the more profitable producers.

Zinc concentrate is a commodity that is shipped from numerous suppliers around the world to end users also internationally distributed. The commodity is somewhat homogenous, and for that reason, prices are determined by a global market much like an international stock exchange. A typical reference for tracking values of concentrate would be the London Metals Exchange (LME)[145] which operates as a world wide market for zinc and other metals. The market validates WTP, in the sense, that the market price is displayed at any one time thus giving a snapshot of the demand but not revealing the relation between price and quantity, which changes with world economic conditions, stockpiles, world political situations, and numerous other variables working to obscure the relationship between price and quantity.

The LME is the world's largest non-ferrous metals exchange and its three main functions are:

- To provide a daily price for its metals, which are relied upon worldwide.
- To provide futures and traded options contracts that allow for prices to be locked in (a risk management function known as hedging).
- To act as a deliverer of last resort by authorizing warehouses to store approved brands of metal. All contracts assume physical delivery but most are usually closed out before they become due—this being the 'insurance' aspect of LME contracts.

The use of daily "prompt dates" is an important difference between the LME and other futures exchanges. It is more commonly seen as a feature of "over-the-counter," bilateral forward markets like the foreign exchange markets. It means that the Exchange combines the convenience of settlement dates tailored to suit individual needs with the security of a clearing house. The value of contracts traded on the LME is about $2,000 billion per year. Volume of business has increased ten fold in the last decade.

Despite the open market aspects of the LME and the policy of transparency it offers, zinc prices undergo periodic swings that are not forewarned by following the market and participating in it. Price swings tend to follow economic cycles and can be up to several years in duration. The unpredictability of zinc price swings has spawned a number of consultants specializing in price predictions and generating predictive models. The predictive models rest heavily on exhaustive analysis of world economic and political situations, regional issues, supplier problems, and other factors implicit in the market price but which camouflage the simple relation between price and quantity. The WTP estimate in this report settles on a popular view of several consultants that, beyond the next few years, zinc prices will fluctuate on either side of $.53, and $.53 will be a frequent central tendency price. This is used as a zinc price in constant dollars throughout the planning period. The price of zinc acts as an upper limit to mine profitability, hence an upper limit on WTP.

**Willingness to Pay (WTP)**. From the point of view of the producer, in this case Red Dog Mine, the production of higher levels of concentrate increases net income of the operation so long as the sale price is above cost, approximately $.31–$.40 (since 1998, a price level adjusted average of $.355), and so long as the concentrate can be shipped. With long-term prices of zinc anticipated to stabilize at $.53, this puts the producers range of WTP at $.355–$.53 lb. The net incremental WTP is $.175.

[145] http://www.lme.co.uk/data_prices/home.html

From the standpoint of the end user, there is also a WTP, although it is a WTP for delivery of an incremental quantity at the destination for use in the metals manufacturing process, in contrast to a WTP for shipment of a raw material from a point of origin. Thus WTP would incorporate a different frame of reference for the end user because of a variance in net income possibilities of the user as opposed to the producer. The end user will have global options available in the form of alternative sources, and his WTP reaches a maximum limit equivalent to the cost of getting supplies from an alternative source, although he cannot rationally pay an amount greater than the net income the commodity will provide. To him the limit of WTP is bracketed at the upper end by how much net income he can earn from the incremental shipment, and at the lower end, by how much he would have to pay for the commodity from an alternative source. In this report, alternative sources are numerous and are treated as a practical choice for the end user. Basically these alternative sources are firms/mines that are able to supply the equivalent increment of induced commodity in the without-project condition.

Alternative sources are available on a world-wide scale which presents an important menu of choices influencing the end users WTP. Looked at in this way, the end user's WTP is somewhat different from the WTP of the supplier, who is very limited in terms of transportation options and hence more concerned about his potential net income losses from not being able to ship, and his erosion of the net income margin from the cost of shipping. In a sense, action and decisions of the producer involve some awareness of the individual end users WTP or demand function, and the manner in which price is assumed to be affected by a move along the demand function following a shift of the supply curve. For all practical purposes, the world-wide demand function is inelastic as prices do not fluctuate enough to induce new end users of the product or render current uses uneconomic.

In the foregoing industry supply curve, the highest cost regularly operating, reliable supplier is about $.405 lb, approximately $.10 lb above cost of producing zinc by buying concentrate from Red Dog, using Red Dog's year 2003 cost for a comparison. Firms operating at cost levels above $.405 lb are truly marginal producers, stepping in and out of production as the world price dictates. Typically they are producers with low quality ore, high extraction cost, short term or spot agreements, and transportation difficulties.

A long term world zinc price is estimated elsewhere in this report (see Commodity Projection) as $.53 lb, and at this price, buying concentrate from the alternative source, which would be an operator at an equivalent finished zinc price at the margin above of $.405, allows for a net income of $.125 lb.

Any source above $.405 would be one of the marginal operators, because the nature of concentrate sales is that deliveries are arranged in advance through buying of futures, and this tends to keep the suppliers operating profitably at cost levels up to the cash price, fully booked. Therefore the end user's WTP criteria would be an amount barely above $.405 as a floor because at any lower price the available concentrate is already profitably sold in a cash deal.

Ultimately, in order to attract a supply increment, the end user must induce one by motivating the marginal operators at the end of the supply curve, and this is all above $.405

lb. The upper limit of WTP for the end user would potentially consume the net income margin for a total maximum WTP of $.53, presenting a WTP range of $.405–$.53.

**Transportation Cost.** The WTP based benefit for each increment of increased production and consumption is the difference between the cost of transportation via the proposed improvement and the maximum cost the shipper would be willing to pay. The mode of transportation by the proposed improvement is by use of direct loading to deep draft carriers; thence direct delivery to ports by a combination of Panamax and Handysize carriers. It is anticipated that future use of the two different sized carriers, which is dictated by destination port limitations, will continue as it has in the past, about an operating ratio of 77%–23% respectively.

As an example and for purposes of generating a constant per ton value, a hypothetical induced tonnage is used.[146] The hypothetical induced increment is 185,000 tons, which represents the difference between 1,544,000 ton present design capacity and a potential (low probability) projected increase to 1,729,000 swt. Using the fleet as established, this equates to 131,600 tons in 2 Panamax vessels, loaded with 65,800 tons each, and a full load for a Handysize vessel, carrying 39,500 tons, with about 13,900 tons left over for the next shipping cycle.

Assuming the optimum depth of the project will allow for full loading of all vessels and assuming the length of each delivery trip to average 14 days for Handysize and 27 days for Panamax,[147] the shipping cost is estimated as follows:

**Table 45. Cost Of Shipping**

| Vessel | Voyage | Cost/Day ($) | Daily Cost/Ton ($) | Trip Cost/Ton ($) | Total Trip Cost ($) |
|---|---|---|---|---|---|
| Panamax, 65,800 dwst | 27 days | 17,448 | .265 | 7.15 | 470,800 |
| Handysize 39,500 dwst | 14 days | 14,440 | .366 | 5.12 | 202,200 |
| | | | | 6.69 Weighted Avg. | |

**NED Benefit.** An NED benefit, referred to as "induced," is derived from the increased production tonnage, which is possible because of effects of a project. In the case of Red Dog Mine, the mine production is constrained by the throughput capacity of the shipping system, in the sense that the mine output has no value if it cannot be delivered to a market. If the zinc can not be delivered to market, the producer incurs a storage cost and the customer experiences a production loss or is forced to seek a higher cost source.

In this study the number of tons shipped in the without-project condition and with any of the alternative plans varies with each alternative as generated by the simulator. One actual case output of the simulator, using a target tonnage projection of 1,544,000 swt, indicated that the without-project condition would ship 1,520,519 tons annually and that a trestle project with a 53 ft channel would ship 1,573,838 tons annually. Since tons in excess of the shipping target are not considered to be marketable, the with-project case would induce 1,544,000–1520,519 = 23,481 tons.

[146] For the actual benefit calculation the shipping simulator is used to calculate tons shipped for each alternative plan.

[147] Derived from a sample of the vessel voyage itinerary in 1999 and 1996.

In this example, the benefit would be calculated as follows: The shipping cost for the 23,481 tons shipped is previously calculated at $149,600, an average of $6.69 per ton or $.003 lb. The difference between the shipping cost at $.003 lb and the maximum the shipper would be willing to pay (a net increment above costs of $.175 in finished metal prices[148] or $.087 in equivalent concentrate prices) is $.084 lb, or a total of $.084 lb x 23,481 tons x 2000 lb per = $3,944,800 annually.

In this study there is adequate data to determine that there is only one level of induced movement and one WTP, because without the project, there is neither an alternative mode nor an alternative port; with the project there is only one level of shipment that maximizes net income consistent with the shipper's management, investment, and operational strategy. Nevertheless, in the interest of recognizing that one would ordinarily anticipate numerous levels of induced movement (ordinarily there would be numerous affected suppliers) at increments of WTP an average WTP is used as a surrogate for the expected average transportation cost that could be borne by the induced traffic. This is assumed to be half way between the highest and lowest costs at which any part of the induced traffic would move having the effect of reducing the above estimated WTP from $3,944,800 to $1,972,400.

Of the 40-year mine life, estimated effectively beginning in year 2002, there are 31 years that are covered by the post 2011 with-project condition. Adjusting the $1,972,400 to a 31-year amount, realized over the first 31-years of the 50-year project economic life, using a discount rate of 5 3/8%, reduces it to **$1,707,900**. The benefit per induced ton is $72.74.

The simulator calculates tons shipped, as an average annual value, running 15 years of weather data on an hourly basis. The annual tonnage levels are:

**Table 46. Induced Tons Using 1,544,000 swt Target Projection**

| Case | Tons Shipped | W-W/O Limited by 1,544,000 | Benefit Value ($) |
|---|---|---|---|
| W/O | 1,520,519 | - | - |
| Alt 2-3 Barges | 1,570,664 | 23,481 | 1,707,900 |
| Alt 3-BW | 1,575,700 | 23,481 | 1,707,900 |
| Alt 4-3 Barges and BW | 1,575,569 | 23,481 | 1,707,900 |
| Alt 5-CH+TR (w/o F)[149] | 1,575,700 | 23,481 | 1,707,900 |
| Alt 6-CH+TU(w/o F) [91] | 1,575,700 | 23,481 | 1,707,900 |
| Alt 7-OF | 1,520,519 | 0 | |
| Alt 8-OF+3B | 1,570,664 | 23,481 | 1,707,900 |
| Alt 9- OF+BW | 1,575,700 | 23,481 | 1,707,900 |
| Alt 10-OF+3B+BW | 1,575,569 | 23,481 | 1,707,900 |
| Alt 11-CH+TR (w/F) | | | |
| CH+TR 47 ft | 1,571,669 | 23,481 | 1,707,900 |
| CH+TR 50 ft | 1,574,219 | 23,481 | 1,707,900 |
| CH+TR 53 ft | 1,573,838 | 23,481 | 1,707,900 |
| Alt 12-CH+TU (w/F) | 1,573,838 | 23,481 | 1,707,900 |

[148] Red Dog's production cost of equivalent finished metal is $.355 based on the average production cost over the 1998–2004 period adjusted for price level.

[149] These alternatives cancel four deep draft tanker calls and increase terminal time for concentrate vessels. Shipments, however, are limited by tonnage targets.

### Table 47. Induced Tons Using 1,729,000 Tons Target Projection

| Case | Tons Shipped | W-W/O Limited by 1,729,000 | Benefit Value ($) |
|---|---|---|---|
| W/O | 1,628,654 | - | - |
| Alt 2-3 Barges | 1,727,389 | 98,735 | 7,182,000 |
| Alt 3-BW | 1,759,506 | 100,346 | 7,299,200 |
| Alt 4-3 Barges and BW | 1,758,504 | 100,346 | 7,299,200 |
| Alt 5-CH+TR (w/o F) [91] | 1,762,187 | 100,346 | 7,299,200 |
| Alt 6-CH+TU(w/o F) [91] | 1,762,187 | 100,346 | 7,299,200 |
| Alt 7-OF | 1,628,654 | - | |
| Alt 8-OF+3B | 1,727,389 | 98,735 | 7,182,000 |
| Alt 9- OF+BW | 1,759,506 | 100,346 | 7,299,200 |
| Alt 10-OF+3B+BW | 1,758,504 | 100,346 | 7,299,200 |
| Alt 11-CH+TR (w/F) | | | |
| CH+TR 47 ft | 1,755,748 | 100,346 | 7,299,200 |
| CH+TR 50 ft | 1,756,385 | 100,346 | 7,299,200 |
| CH+TR 53 ft | 1,762,187 | 100,346 | 7,299,200 |
| Alt 12-CH+TU (w/F) | 1,762,187 | 100,346 | 7,299,200 |

# 7.0 FUEL TANKER/FUEL BARGE SERVICE PATTERNS

**Purpose**. The purpose of this section of the Economics Appendix is to explain how fuel delivery to Portsite will change fuel delivery patterns by allowing for lower cost delivery of fuel to area villages. It summarizes the practices involved in fuel transportation, the areas served, equipment used, problems encountered, and economic costs.

In the without-project condition some of the villages rely on ocean barge delivery to locations offshore where lighters are used to connect with tank farms or to reship to village locations. Some village destinations rely on delivery through Nome, Kotzebue, or by a direct barge shipment from Puget Sound, or by barge service on the Yukon River. All of these routings are changed to a lower cost pathway from Singapore through Portsite in the with-project condition.

Seasonality is a major issue in transportation planning in arctic areas. For example, delivery can be closed off by ice for over half the year, and since there are no roads connecting the communities with the rest of Alaska, shipment by air is the only practical alternative to bring goods into Kotzebue, Nome, Portsite, or any of the coastal villages.

To the extent that adverse effects may be avoided by harbor improvements proposed at Portsite, there is a basis for estimating NED transportation savings. In general, transportation savings are most obvious when they arise from visible changes in activity or investment, such as from more efficient routings, shifts of origin, and use of equipment combinations which operate at a lower overall unit cost. A positive economic effect for area villages of an improvement at Portsite is that fuel delivery is able to be made from a different source, and a deep draft tanker is able to be used for delivery, thereby achieving a lower cost point of purchase and significant economies in shipping over the present barge delivery mode. Even considering the need to deliver to final destinations by use of barge-lighter combinations working out of Portsite, a major transportation cost saving is present. Part of the overall saving at the final lay down destination is because use of a deep draft tanker also makes it possible to buy fuel at foreign ports at lower cost than the present domestic sources.

Alaska is a leading U.S. supply source of crude oil, ranking 2$^{nd}$ in crude oil reserves and 3$^{rd}$ in crude oil production (including Federal Offshore); however, much of the heating fuel in this study is from out of state sources. The Alyeska Pipeline connects the North Slope oil fields with the Port at Valdez, and from Valdez, crude oil is shipped primarily to California. Small quantities of crude oil are exported to Asia from fields under state waters of Alaska's Cook Inlet. Alaska has 6 refineries with a combined crude distillation capacity of nearly 360 thousand barrels per day, and most of the refinery capacity comes from a topping off process that yields the lighter products from the crude stream that runs the refineries. Refinery capacity on the Kenai Peninsula is 72 thousand barrels per day, and the capacity is used to process crude from various sources including Alaska and foreign nations. Nevertheless fuel can be purchased at lower cost from foreign sources.

**Cost Difference Between Domestic and Foreign Production, Refining, and Distribution**. Of the total benefit for fuel cost savings, about 30% is attributed to transportation cost savings by using large foreign-flagged tankers from Singapore instead of small barges towed by American-flagged vessels to deliver fuel from Seattle. The remainder, about 70% is due to paying 15 cents per gallon less by purchasing fuel at Singapore. The 15 cents represents a five-year average from 1998 to 2002. Over the 15 years from 1988 to 2002, the average savings was 8.7 cents per gallon, but the savings has grown each year since 1988 averaging 15.52 cents per gallon over the most recent three years. There are sound economic reasons for the savings to increase with time and to persist over the planning period.

**Table 48. Fuel Oil Cost Savings Singapore vs. Seattle**

| Price Comparison Period | Cents Per Gallon Difference Singapore vs. Seattle |
|---|---|
| 3 years 2000–2002 | 15.52 |
| 5 years 1998–2002 | 14.65 |
| 11 years 1992–2002 | 10.82 |
| 15 years 1988–2002 | 8.66 |

Singapore fuel is cheaper, because the crude oil cost and refinery cost/margin, which make up about 69% of refinery product prices,[150] are both steadily becoming more advantageous in Singapore than on the west coast of the U.S.

The larger foreign refiners have a considerably lower operating cost, based on size and labor source. Singapore also has the advantage of newer higher technology refineries, built since 1988, while during this period, refinery expansion and modernization in the U.S. has been practically non-existent. For example refining capacity for the west coast of the U.S. has increased only from expanding existing refineries with Washington showing a 9.16% increase from 1996, and California a 1.47% increase; while foreign refinery capacity in Indonesia, Singapore, Twain, and South Korea has increased by 23%, 8%, 70%, and 105% respectively. On a net basis in the U.S., energy companies have closed more than half of their U.S. refineries since 1981, due to a squeeze on profits and environmental regulations.[151] The ages of remaining plants and economies of scale are important factors in refinery economics, and U.S. refineries show a disadvantage in both areas.

Over time, within the U.S., plant retirements have caused the refinery supply curve to be shifted to the left, thus driving up the domestic product cost. Meanwhile a strategic expansion of refinery capacity in Singapore has shifted their supply curve to the right, driving prices down. Refinery investments are long-term commitments, and the new refineries are anticipated to be in operation for decades. These supply curve shifts over the last 10–20 years explain why Singapore heating oil and gasoline is cheaper than heating oil and gasoline that can be purchased on the U.S. west coast.

All of the foreign refineries are significantly larger than those in the U.S. Average refinery size as measured by daily capacity is listed below:

[150] Calculated from year 2001 production cost data found at http://www.energy.ca.gov./gasoline/margins/1997–2001_branded_graphs.gif.

[151] Lack of refineries contributes to soaring gas prices, Doug Abrahms, Gannett News Service, March 6, 2004.

**Table 49. Average Refinery Size**

| Location | Daily Capacity | Refineries | Average Size |
|---|---|---|---|
| Indonesia | 992,745 | 8 | 15,512 |
| Singapore | 1,258,500 | 3 | 139,833 |
| China-Taiwan | 920,000 | 4 | 57,500 |
| South Korea | 2,550,600 | 5 | 102,024 |
| Alaska | 384,500 | 6 | 10,681 |
| Washington | 620,420 | 5 | 24,817 |
| California | 1,893,020 | 14 | 9,658 |

In addition to being able to refine raw material at less cost, foreign refineries are also in a position to purchase crude at lower prices. Crude oil is the world's most actively traded commodity. The largest markets are in London, New York, and Singapore.

Because there are so many different varieties and grades of crude oil, buyers and sellers have found it easier to refer to a limited number of reference, or benchmark, crude oils. Benchmarks are Brent, Dubai, and WTI (west Texas intermediate). Other varieties are referenced to a specific benchmark and priced at a discount or premium, according to their quality.

Singapore refineries have larger capacity plants so they are more able to take larger size deliveries, and they are closer to foreign crude sources. Each crude source has a different yield value for various products, and specific refineries are designed to be most efficient with a particular crude supply. Nevertheless the price of crude delivered to different locations is a significant cost variable for refinery operations. For example, Dubai delivered to Singapore is delivered for $5.08 less than WTI and $1.80 less than ANS delivered to the west coast.

New refinery complexes, integrated with deep draft shipping facilities, place Singapore at a definite cost advantage, compared to the west coast refineries of the U.S. Recent years have left much of this Singapore capacity as a "surplus," because some historic trading partners, receiving Singapore products, have built their own refinery capacity.

The fuel oil price differential, which has been growing over the last 15 years, is anticipated to be maintained at least at 15 cents per gallon during the planning period. Confidence in the durability of this differential is based on the fact that Singapore enjoys definite economic advantages. and it is unlikely that new refineries able to operate at a higher level of efficiency will be built in the U.S. This projection of a persistent price differential for bulk shipments by deep draft carrier to Portsite is projected to be durable also because Singapore is not the only low cost foreign source. If for some reason Singapore was not able to act as the supply point, similar price benefits are available by purchases through Indonesia, South Korea, and Taiwan.

It has been asked, with fuel oil cheaper, when purchased through Singapore or other foreign countries, why then is it not imported to the U.S. in the without-project condition? The answer is that it is imported in the without-project condition, however, not due to Singapore prices but as an enhancement of the economics of refinery production in the U.S. Generally speaking, one barrel of crude oil makes about 19½ gallons of gasoline, 9 gallons of fuel oil, 4 gallons of jet fuel, and 11 gallons of other products, including lubricants, kerosene, asphalt, and petrochemical feedstocks to make plastics.[152] West coast U.S. imports are summarized below for a sample year.

**Table 50. Pad District V: Imports By Country Of Origin 2002, 1,000 Barrels**

| Country of Origin | Crude | Gasoline | Fuel Oil |
|---|---|---|---|
| OPEC | | | |
| Algeria | 0 | 27 | 0 |
| Iraq | 39,952 | 0 | 0 |
| Kuwait | 3,808 | 0 | 0 |
| Qatar | 3,194 | 0 | 0 |
| Saudi Arabia | 36,962 | 0 | 0 |
| UAR | 3,505 | 150 | 0 |
| Indonesia | 18,246 | 0 | 0 |
| Venezuala | 2,065 | 0 | 0 |
| | | | |
| NON-OPEC | | | |
| Angola | 17,552 | 0 | 0 |
| Argentina | 19,704 | 0 | 0 |
| Australia | 17,093 | 0 | 0 |
| Belgium | 0 | 10 | 0 |
| Brunei | 3,163 | 0 | 0 |
| Canada | 21,266 | 713 | 1,641 |
| China | 6,478 | 24 | 2 |
| Colombia | 2,190 | 0 | 0 |
| Eucador | 28,329 | 0 | 0 |
| Egypt | 0 | 33 | 0 |
| Gabon | 1,973 | 0 | 0 |
| Germany | 0 | 92 | 0 |
| India | 0 | 0 | 150 |
| Korea | 0 | 1,679 | 98 |
| Malaysia | 2,543 | 25 | 141 |
| Mexico | 18,933 | 0 | 0 |
| Netherlands | 0 | 530 | 0 |
| Norway | 4,308 | 0 | 0 |
| Oman | 6,060 | 0 | 0 |
| Panama | 0 | 4 | 75 |
| Peru | 1,128 | 0 | 0 |
| Protugal | 0 | 81 | 0 |
| Russia | 0 | 95 | 0 |
| Singapore | 0 | 2,039 | 38 |
| Thailand | 675 | 60 | 0 |
| Virgin Is | 0 | 39 | 0 |
| Other | 8,729 | 55 | 0 |
| Total | 275,740 | 5,988 | 2,143 |

Source: Energy Information Administration (EIA) form EIA-814, Monthly Imports

Less than 10% of the U.S. petroleum needs are west coast imports. United States refineries produce over 90% of the gasoline used in the United States. Less than 40% of the crude oil

[152] Compiled by Dick Gibson, Gibson Consulting, 301 N. Crystal St., Butte, MT 59701, http://www.gravmag.com/oil.html.

used by U.S. refineries is produced in the United States. About 45% of gasoline produced in the United States comes from refineries in the U.S. Gulf Coast (including Texas and Louisiana).

Overall the U.S. refinery capacity is engineered to refine crude into approximately 45% gasoline, 21% fuel oil, 10% jet fuel, and 24% other products. If the demand for fuel oil exceeds domestic refining capacity and the amount in domestic storage, then imports of already refined products must be arranged. These imports are very low quantities and practically all of them arrive at east coast U.S. ports. Generally fuel oil imports are very insignificant, being as low as zero in some months to a high of around 300,000 barrels in colder months, such as February using data from 1996–2000.[153]

Instead of importing fuel oil and gasoline, it is more economical to run refineries at levels where 100% of the product mix produces revenue. So, imports of fuel oil and gasoline are avoided when refinery output and domestic storage stocks are in balance with the markets demand. Imports, at such a time of equilibrium, otherwise would require either cutting back the refinery output level of all products and losing a profit on the entire bundle, or selling the amount in excess of available storage space at a distress market clearing price. Either case can produce economic losses greater than the potential 15 cents per gallon saving offered by the foreign vs. domestic price differential. These disadvantageous situations are avoided by tailoring the import of fuel oil and gasoline carefully to fill anticipated gaps thus serving the market while efficiently running domestic refineries. This logic explains why both fuel oil and gasoline imports are not a major percentage of fuel consumed in the U.S.

This Economic Analysis Appendix does not delve into the fact that a popular theme in the literature is that the real cost of oil in a product is anticipated to rise as world supplies dwindle. As time goes on more purchasing power will need to be given up to obtain a given quantity of fuel. In that sense, the price of oil products is anticipated to grow more rapidly than other commodities. This relative price effect has not been included in the analysis nor has the anticipated continued shift of the supply curve, making the $0.15 differential in the cost of fuel oil somewhat of an understated long-term expectation.

Furthermore, it is very expensive to ship refined products to the west coast from the nearest major refining center, the gulf coast, in part because of the Jones Act requirements that such shipments be made on U.S. built, owned, and crewed vessels, but also because of size restrictions in the Panama Canal as well as its costs, and the lack of a gasoline pipeline alternative. Moreover, even provided a company succeeded in bringing CARB gasoline from the gulf coast or the Caribbean, it is not trivial to get the gasoline to consumers. In particular, transporting gasoline to consumers requires terminal facilities and retailing facilities, which are in large part controlled by incumbent refiners. Thus, it is unlikely that imports of gasoline will enhance west coast supply at current, or even moderately higher, prices. However in the with-project condition imports of gasoline from Singapore directly to Alaska avoid much of this and produce an economic saving.

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[153] *EIA Projections: Short Term Energy Outlook*, August 2002 at http://www.naseo.org/events/winterfuels/2002/presentations/Caruso.pdf .

For gasoline the prospects for saving more than 15 cents per gallon of gasoline are very good. The wholesale price differential between buying at Singapore (the with-project condition) and buying at Seattle or Anchorage (the without-project condition), averaged over the last three data years, has been nearly 28 cents per gallon. Gasoline makes up less than 12% of regional fuel needs.

**Local Distribution.** It has been observed that where there is more than one seller of fuel in a village, competition lowers the price. An example is a 2003 comparison of retail gasoline prices between Nome $2.41 (two sellers) and Kotzebue $2.89 (one seller), making a difference of 48 cents per gallon. About 25 cents of the difference is due to higher shipping cost to Kotzebue, indicating about another 23 cents per gallon can be saved if competition is introduced or if a non-profit cooperative is created.

On a limited scale, cooperative type of buying exists in the North Slope Borough (NSB). In order to accommodate the needs of all NSB departments for power generation, facility heating, equipment operations and subsidized residential home heating, the Fuel Division of the NSB is responsible for the purchase and handling of all diesel fuel and heating oil. Typically this will include over 3 million gallons of fuel for the coastal villages and a combined 1 million gallons for the villages of Nuiqsut and Anaktuvuk Pass. Management of the fuel in each of the villages is currently accomplished through contracts with the local Village Corporations. Implementation and oversight of these contracts is done from the Fuel Division main office in Barrow. The NSB operation is a practical demonstration that there are economies of scale that can be taken advantage of when small users have a vehicle for combining purchases into a single large order.

When Portsite is online as a fuel storage and transfer facility, there will be an opportunity for all of the end-users to combine their needs into a collective purchase at Singapore prices. At present there is no incentive to do this as there is no storage and redistribution point that can be used for the final leg to the villages. This is why fuel is barged in from the Puget Sound and Kenai areas.

In the with-project condition more than one distribution option is present. Existing fuel sellers could perform the bulk buying service and use the Portsite storage and transfer tank farm to reduce the cost of their operations. It is also possible for end-users to bind together as a non-profit cooperative to assure that the point of purchase savings are passed along to the consumers instead of becoming retained profits. Either way, there is significant incentive for Portsite to be put into actual use as part of a fuel delivery system.

With or without the development of Portsite, the regional fuel needs are the same. Taking advantage of Portsite merely results in a major financial reward for those who participate in a cooperative purchase plan or the established fuel delivery firms that change their purchase and delivery plans to develop lower cost delivery systems via Portsite.

**With-Project and Without-Project Condition.** In the with-project condition, purchasing the fuel at Singapore and transferring it to barges through the Portsite tank farm minimizes the cost, while at the same time, eliminating most of the distance of the barge haul from the redistribution point.

In the without-project condition delivery of cheaper fuel into Dutch Harbor or Anchorage by deep draft vessel would still require redistribution by barge to all of the village destinations.

Redistribution from the Anchorage area is consistent with the without-project condition that is used in the report, because fuel is now being barged from both Puget Sound and the Anchorage area to village destinations.

Singapore fuel has been shipped to Puget Sound, the Anchorage area, and Dutch Harbor. Dutch Harbor has regularly received fuel delivery by tanker from Singapore.[154] Dutch Harbor, however, is not one of the interim redistribution points for the northwest villages for several compelling economic reasons that will continue to exclude it from being part of the "most likely future" condition. Generally, Dutch Harbor lacks the necessary infrastructure in terms of tank storage locally, unused capacity being inadequate to serve the coastal villages of Northwest Alaska. Dutch Harbor firms also lack ownership of northwest coastal tank storage needed for redistribution in the without-project condition. Without coastal tank farms, the delivery link from Dutch Harbor to the northwest coastal villages would require many long lighter trips, and according to fuel suppliers at Dutch Harbor, the high transportation cost is what renders the proposition uneconomic.[155]

The Dutch Harbor vicinity, on the Aleutian chain, is also subject to horrendous storms that could cut down the delivery window and create the possibility that fuel deliveries might not be made. These factors combine to generate a high cost expansion into the northwest coastal village market, making Dutch Harbor uncompetitive. Also the weather related problems create a lower level of reliability and could lead to the necessity of delivery of fuel by air, a very costly proposition.

Lower cost fuel has been available from Singapore and other foreign sources for over 15 years, and for some years, it has been even cheaper than the $0.15 average saving per gallon noted in this economic analysis. Even this long history of potential fuel price savings that could result from buying deep draft lots at Singapore has not lead to establishment of Dutch Harbor as a fuel supply point for the northwest Alaska villages. One reason is that at Dutch Harbor, construction of a fuel terminal would be required. The three fuel suppliers presently operating at Dutch Harbor usually obtain their supply in barge-sized lots from Puget Sound and Kenai and on occasion from Singapore by tanker. The tank farm has about 2 million gallons of capacity in reserve, which is insufficient storage to accommodate the fuel needs of the northwest Alaska villages that could be served from Portsite.

There is no plan to expand services to include the additional villages. The 32,825,300 gallons of fuel used by the villages would require from 32,825,300 to 65,650,600 gallons of storage to back up the delivery system. The minimum amount would be required at Dutch Harbor, and the maximum amount recognizes that regional staging and final delivery storage would also be required.

All of the Dutch Harbor facilities are now owned by three fuel suppliers, operating their own fleet of delivery vessels, which also would have to be expanded. The new fixed and floating plant would be at a disadvantage in serving the northwest coastal villages, because it would be in competition with companies using equipment and tank farms that have been largely amortized by being in service for years.

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[154] Personal communication with Ed Hammond, Delta Western Port Manager, Dutch Harbor, Alaska.

[155] Personal communication with Mike Posten, Delta Western Contracts Manager, Anchorage Alaska.

Nevertheless, a point of purchase saving of $0.15 per gallon could provide adequate resources to amortize the necessary new investment, although practically, all of the $0.15 per gallon savings would be dedicated to this leaving only $0.02–$0.03 per gallon for the NED savings after adjustments for this associated cost. This low potential gain is tainted by the fact that market size is essentially fixed and any expansion of the delivery area, served by a particular company, can only be done by taking market share from others. The small margin and limited market for a regional fuel supply operation out of Dutch Harbor would be short lived, because it would not be able to compete with one coming online at Portsite. Given the short life and limited earning potential, the investment in necessary infrastructure could not be recovered.

Looking at the prospects for Portsite to become a regional fuel terminal and then assuming this opportunity is equivalent to opportunities available at Dutch Harbor, ignores the drastic differences between the two operations. Portsite has an existing tank farm that is available for summertime use when the fuel service to villages is performed. The Portsite storage availability stems from the cyclical needs of Red Dog Mine, which is to have the tanks replenished with the first delivery of the ice free season and then to have them filled for winter as the last delivery of the ice free season. Essentially they are available to store fuel for transshipment to villages from July thru September. In contrast, the facilities at Dutch Harbor are used year around to furnish fuel to fishers, processors, and freighters.

Since the Portsite operation does not need to add extensive infrastructure specifically to be developed as the fuel transshipment terminal, it has a definite economic advantage. It is also favored by the fact that delivery distances from Portsite are much shorter than from Dutch Harbor. The fuel operators at Dutch Harbor are aware of this disadvantage, and being rational decision makers, are not likely to risk financing of a tank farm knowing that they probably would not be able to make a profit. There is not adequate time for Dutch Harbor entrepreneurs to recover their investment before the projected online date of the Portsite project; they would be at a dire competitive disadvantage when the with-project condition develops.

Although it is considered to be unacceptable, as the most likely future condition, because it is not a rational choice; if one were to assume that Dutch Harbor would become the regional fuel terminal in the without-project condition and if project benefits for the NED plan are based on that assumption, then project net benefits would be reduced by about $2 million per year.[156] The NED plan B:C would still be well over 1 and the plan formulation would be unaffected.

Questions have also been raised about the suitability of Adak as an alternative fuel distribution center. Adak, population 150, is located on Kuluk Bay on Adak Island. It lies 1,300 miles southwest of Anchorage and 350 miles west of Unalaska/Dutch Harbor. It lies in the maritime climate zone, characterized by persistently overcast skies, high winds, and frequent cyclonic storms. Winter squalls produce wind gusts in excess of 100 knots.

[156] Low range estimate using gallons in the draft report, associated cost of storage at$.975 per gallon, zero cost for added floating plant, and a 33% distance reduction for operating out of Dutch Harbor compared to the Kenai Peninsula.

After the WW II, Adak was developed as a Naval Air Station, playing an important role during the Cold War as a submarine surveillance center. Large earthquakes rocked the Island in 1957, 1964, and 1977. At its peak, the station housed 6,000 naval personnel and their families. In 1994, severe cut-backs occurred, and family housing and schools were closed. The station officially closed on March 31, 1997, and currently houses civilians. The Aleut Corporation acquired Adak's facilities under a land transfer agreement, pending with the Department of the Interior and the U.S. Navy/Department of Defense. Properties are currently under lease. About 30 families with children relocated to Adak in September 1998, most of them Aleut Corp. shareholders, and a school was reopened. Aleut Corp. is currently developing Adak as a commercial center. The community formed a Second Class City government in April 2001. The former naval base has some 20,000,000 gallons of tank storage.

Adak has Aleut Enterprises, which has delivered Russian fuel directly from Russia and offloaded it in Adak. Aleutian Enterprises has established the edge of its service perimeter as Bethel, the Kuskokwim River, and communities on the Alaska Peninsula. None of these areas include any of the 47 villages that could be advantageously served from Portsite.

As a potential fuel transshipment point for western Alaska, the location is problematic because of the weather and remoteness. The lighter link to end use villages would well exceed 1,300 miles across the open Bering Sea. It is crucial to the economics of fuel redistribution to minimize lighter distances, since lighter service adds drastically to the cost per gallon delivered. This is because the lighters are small, and the operating cost is therefore not spread over a huge volume such as when calculating the cost per gallon of ocean delivery by tanker. A complicating factor is that fuel sales in recent years show that Adak prices are higher than Dutch Harbor, and even Dutch Harbor has not been able to compete.

**Destinations**. The discussion of multi-use aspects of this report centers on the delivery of fuel through Portsite in the with-project condition to 47 villages grouped into geographic areas as shown below. Grouping them by geographic area makes them easier to find on a map; however, in the text they are grouped somewhat differently, because it is necessary to associate them with delivery nodes and delivery methods which are not necessarily directly related to the geographic listing below. Where the regional economy is discussed in The Regional Economic Base section of this appendix, they are grouped by political and census subdivision so that the statistical data can be viewed without overlap or duplication.

**Table 51. List Of Villages Receiving Fuel Delivery By Water**

| Norton Sound/Bering Sea | Yukon River & Delta | Kobuk River | Kotzebue Sound | Chukchi Sea/Beaufort Sea |
|---|---|---|---|---|
| Nome | Alakanuk | Ambler | Kotzebue | Point Hope |
| Brevig Mission | Emmonak | Kobuk | Deering | Point Lay |
| Diomede | Kotlik | Shungak | Selawik | Wainwright |
| Elim | Pilot Station | Kiana | Kivalina | Barrow |
| Gambell | Marshall | Noorvik | | Kaktovik |
| Savoonga | Mt Village | Buckland | | |
| Golovin | Pitkas Point | | | |
| Koyuk | St. Marys | | | |
| St. Michael | RussianMission | | | |
| Shaktoolik | Holy Cross | | | |
| Sishmaref | Anvik | | | |
| Stebbins | Shugeluk | | | |
| Teller | Grayling | | | |
| Unalakleet | Kaltag | | | |
| Wales | Nulato | | | |
| | Koyukuk | | | |
| | Galena | | | |

In addition to those listed above, there are other villages which will incidentally be at an advantage because of the project, even though they do not take their final delivery link by water. This incidental benefit arises for any village which receives fuel staged through Kotzebue, Portsite, Nome, or Barrow, because any such village will enjoy a lower price with the project regardless of the final link. This study, however, has set aside the non-water final links, because it is anticipated that they account for a minor amount of tonnage and the economics of the overall transportation system will not be materially influenced by their exclusion on the grounds of seeking a measure of simplicity in an otherwise complicated evaluation.

The delivery system is complex, and the effects of the proposed project are easy to identify conceptually, but difficult to trace and describe. Wherever possible the analysis has been simplified when reliability and quality of the results are not compromised. The two following conceptual drawings show the political boundaries from which data was gathered and also show the transportation routings of fuel in the without-project condition and in the with-project condition.

Gallons of fuel oil and gasoline shipped through each main distribution point are based on interviews with managers at various distribution sites and actual records. The number of gallons distributed to some of the smaller villages varies from year to year. In some years the amount might be zero, due to carryover; however, the numbers herein reflect deliveries that could be expected in a typical year with no significant carryover from the prior year.

Most of the village fuel oil data comes from actual records; however, actual gasoline use at a few villages is undocumented. Local gasoline use is estimated by disaggregating the known larger area consumption to specific villages. The disaggregating is based on per capita consumption data from 4 remote coastal villages and 8 closely situated river villages.[157] The two per capita use rates are used for the two different village groups.

[157] Gasoline represents about 8% of total fuel use for small remote coastal villages based on Pt. Lay, Pt Hope, Wainwright, and Kaktovik. Riverine villages in closer proximity to one another have a use rate of 25% based on Shugnak, Ambler, Kiana, Noorvik, Selawik, Buckland Deering, and Kivalina.

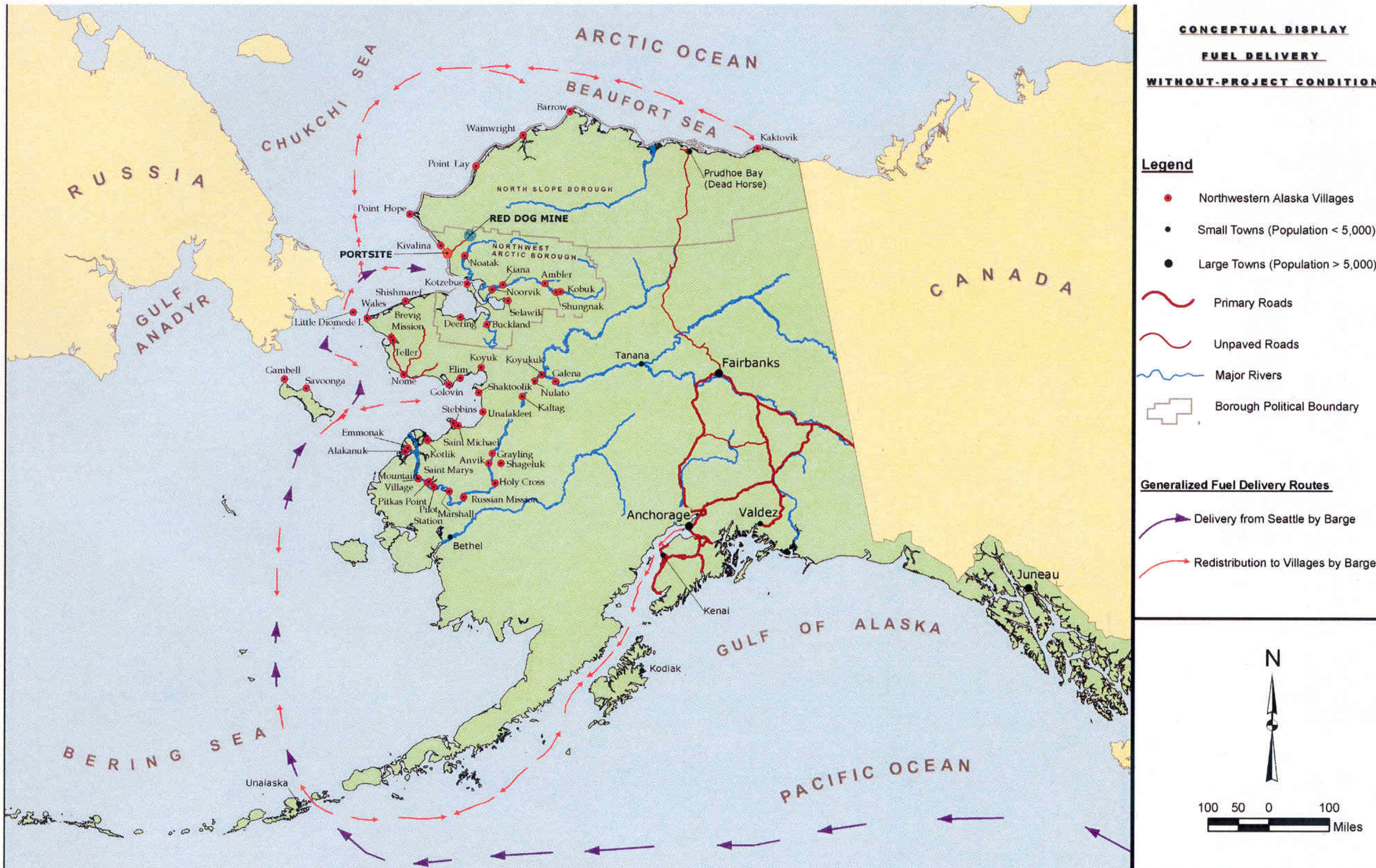


Figure 6. Conceptual Display Of Fuel Delivery In The Without-Project Condition (Redistribution To Villages Not Shown)


Figure 7. Conceptual Display of Fuel Delivery in the With-Project Condition (Redistribution to Villages Not Shown)

The project effects are identified by breaking the discussion into six delivery scenarios. Each scenario describes delivery to a subset of destinations sharing a common routing either in the with-project or without-project condition:

Scenario 1. Without-project fuel delivery to Kotzebue of 7,750,000 gallons (includes 800,000 gallons of gas) from Puget Sound by Crowley Marine barge service, then 1,750,000 gallons (includes 437,000 gallons of gas) by lighter from Kotzebue to 9 other final village destinations and by air to one. In the with-project condition, delivery will be by deep draft tanker from Singapore to Portsite, then delivery by lighter from there to final village destinations including Kotzebue.

Scenario 2. Without-project delivery of 6,427,000 gallons (includes 1,927,000 gallons of gas) by an ocean tug/barge combination to 5 coastal villages directly from Puget Sound. In the with-project condition delivery to these villages plus two others will be by deep draft 55,000 dwst tanker from Singapore to Portsite, then delivery by lighter from there to this subset of 7 village destinations, referred to as "Swing Villages" in the discussion.

Scenario 3. Without-project delivery of 10,000,000 gallons (includes 2,000,000 gallons of gas) from Puget Sound to a tank farm at Nome by Crowley Marine barge then by lighter meeting partial needs of 14 villages, delivered from Nome (1,400,000 gallons including 300,000 gallons of gas). In the with-project condition delivery will be by deep draft tanker from Singapore to Portsite, then delivery by barge from there to the Nome tank farm. From there, lighters will take over for delivery to 14 coastal village destinations.

Scenario 4. The balance of fuel needs (3,019,600 gallons including 242,000 gallons of gas) for the 14 villages in the vicinity of Norton Sound, also delivered by lighter from Nome, is supplied directly from Puget Sound. The delivery is direct by ocean barge or ocean barges with lighter assistance on the final leg to the coastal villages. With the project, delivery is by the same type of equipment; however, the trip originates from Portsite. These are identified as "Village Direct" in the discussion.

Scenario 5. 5,628,700 gallons (includes 1,407,100 gallons of gas) to 17 Yukon River villages delivered from Tanana or Bethel in the without-project condition and from Nome in the with-project condition. The 7 most upstream villages in this group are referred to as "Yukon Swing Villages." Fuel for unaffected villages is delivered to Tanana from a refinery at North Pole in both cases.

Scenario 6. Delivery of 25,712,900 gallons to Portsite (no gas is used at Portsite) by barge from Puget Sound and Kenai via Kotzebue in the without-project condition and delivery by deep draft tanker from Singapore with 58,746,700 gallons (includes 6,807,000 gallons of gas) in the with-project condition. In the with-project condition Portsite becomes a regional fuel center and Kotzebue is bypassed.

For 12 of the destinations served from Nome and for the 13 villages delivered direct by ocean barge, the last leg of the delivery is the same as the without-project condition. Since the delivery from Nome to these village destinations or the direct delivery to the village itself is basically unchanged, the only cost comparison for those destinations in this scenario is for the primary link. In the first case this would be delivery to Nome as the distribution point, and in the second case, it would be the link to an offshore transfer point at the destination.

A group of the 7 most upstream villages on the Yukon River that will be delivered from Tanana in the without-project condition are referred to as the "Yukon Swing Villages" throughout the discussion. This "Yukon Swing Village" term is not applied to the 10 more downstream "Yukon Delta and Lower River" villages, which are delivered from Bethel. The reconstructed economic cost of delivering to these downstream villages is nearly the same whether the shipment is sourced at Bethel or Nome.

The decision to identify Bethel as a source, in the without-project condition, is based on the non-NED financial advantages it appears to provide to the shipper. Bethel is the most likely source considering that there appears to be a small NED saving bundled with a private sector shipping strategy to protect/expand market share. The private sector motivation is an apparent commitment to protect a return on sunk costs (new tank farm). This is not necessarily an efficiency gain for the region or the nation but a company strategy. Nevertheless, as a private sector decision, it influences the most likely future delivery pattern.

The identification of the many village destinations, which could be potential beneficiaries, was based on calculation of the added service distance that would be provided by the reduced transportation cost, then identifying villages in that distance band from the location of Portsite. Villages at the limit of the newly expanded perimeter would have a saving decaying to zero at the extended perimeter. All of the final 47 village destinations benefit in terms of overall savings to end users.

**Fuel Use and Cost.** None of the analysis of either the with-project or without-project condition is dependent on economic projections of growth in fuel consumption in the study area. This is primarily because over the last 20 years, fuel oil use in the state has not shown an appreciable increase.[100] A review of the state and regional economy shows there are no concrete economic changes of a structural nature on the horizon which would bring about a change in patterns of use or amount of use.

A comparison of residential fuel use over a 30-year period shows that average use in 1967, 1968, and 1969 differed from average use in 1997, 1998, and 1999 by only 8%. Single year fluctuations up or down during the 30-year span exceeded 25%. An economic base study has disclosed no convincing reason to believe that population growth rates, which have prevailed in the villages for the last few decades, should be anticipated to change. This does not discount the almost certain eventual economic development of northwest Alaska keyed to management and use of its abundant storehouse of mineral riches. Nor does it discount the need for a regional transportation strategy to seed the development; it merely makes a statement of the indefinite nature of a development timeline and the uncertain link between it and fuel needs in general.

The following fuel cost range-estimates are derived from the Alaska Village Electric Coop (AVEC) rate calculation for diesel electric generation at 29 villages in year 2002 by using a range of efficiency factors.[101] The factors represent a possible fuel consumption range from .039 gallons per kWh for a 500 kWh stationary van unit to .077 gallons per kWh for a portable 13.5 kWh unit. For purposes of arriving at the typical range of fuel cost, data for 2002 is used as a

[100] State residential heating oil consumption accessed at http://www.eia.doe.gov/emeu/states/sep_use/total/pdf/use_ak.pdf. See Table 8.

[101] AVEC does no longer maintain a record of delivery cost to specific locations but has cost records pertaining to area deliver contracts for groups of villages. Details of generator efficiencies at specific locations are not available.

"normal" year. The high efficiency column is the most likely estimate, providing loads are reliably met by capacity of the newer generating units. Indications are that there has been a constant effort to upgrade unit efficiency, and as this takes place over time, lower efficiency units become reserve capacity. Therefore an outage of primary capacity can call a backup unit online and shift the average efficiency of the entire plant downward

It can be seen that fuel costs vary widely from location to location within the study area. They tend to fluctuate from year-to-year as well. Based on the assumption that high efficiency generators are typical of village operations, the average cost per gallon of fuel oil, delivered to a sample of villages in the study area in 2002, is estimated to vary from $1.12 for lighter delivery at Russian Mission to $2.99 per gallon at Noatak for a combination of barge and air.

The price of retail sales would be expected to be somewhat higher as storage, transfer, finance, risk, and profit are accounted for. The fuel costs vary from year to year, based on delivery difficulties, fuel origin, purchase cost peaks and valleys, and trends in generator efficiencies resulting from modifications, outages, replacements, maintenance, upgrades, and numerous other variables.

**Table 52. Range Estimate Of Delivered Fuel Oil Cost To Selected Villages**

| Sample Villages | High Efficiency Low Cost ($) | Mid-range ($) | Low Efficiency High Cost ($) |
|---|---|---|---|
| Alakanuk | 1.18 | 1.76 | 2.34 |
| Ambler | 1.92 | 2.86 | 3.83 |
| Anvik | 1.88 | 2.81 | 3.73 |
| Brevig Mission | 1.17 | 1.75 | 2.32 |
| Elim | 1.31 | 1.95 | 2.59 |
| Emmonak | 1.30 | 1.94 | 2.57 |
| Gambell | 1.04 | 1.55 | 2.06 |
| Grayling | 1.73 | 2.59 | 3.44 |
| Holy Cross | 1.53 | 2.29 | 3.04 |
| Kaltag | 1.65 | 2.47 | 3.28 |
| Kiana | 1.82 | 2.72 | 3.62 |
| Kivalina | 1.88 | 2.80 | 3.72 |
| Koyuk | 1.15 | 1.72 | 2.29 |
| Marshall | 1.14 | 1.73 | 2.31 |
| Mt. Village | 1.22 | 1.82 | 2.42 |
| Noatak | 2.99 | 4.43 | 5.89 |
| Noorvik | 1.85 | 2.76 | 3.67 |
| Nulato | 1.67 | 2.50 | 3.32 |
| Pilot Station | 1.13 | 1.69 | 2.25 |
| Russian Mission | 1.12 | 1.68 | 2.23 |
| St. Mary's/Pitkas | 1.46 | 2.18 | 2.90 |
| Saint Michael | 1.41 | 2.10 | 2.79 |
| Selawik | 2.22 | 3.31 | 4.40 |
| Shageluk | 1.54 | 2.30 | 3.06 |
| Shaktoolik | 1.19 | 1.78 | 2.37 |
| Shishmaref | 1.17 | 1.76 | 2.34 |
| Shungnak | 1.45 | 2.17 | 2.89 |
| Stebbins | 1.21 | 1.81 | 2.40 |
| Wales | 1.22 | 1.82 | 2.43 |
| Average | 1. 50 | 2. 24 | 2. 99 |

**Wind Energy As an Alternative to Diesel Generation.** Selection of a suitable site is key to the economics of wind energy. In general, winds exceeding 5 m/s (11 mph) are required for cost-effective application of small grid-connected wind machines.

Wind generators have been installed in Kotzebue, Wales, and Selawik; however, most of the village electricity has been and will continue to be produced using diesel generators. As revealed by the Kotzebue installation, wind cannot totally replace the backup diesel capacity, because wind is sufficient to drive the generators there only about 13% of the time. The relatively low plant factor can cause the main diesel generators to cycle on and off and to run at loads below their design rating, thus causing an increase in fuel consumption and in maintenance cost per kWh of output. Ignoring these factors, approximately one gallon of fuel is saved for each 14 kWh produced by the Kotzebue Electric Association (KEA) wind farm.[102]

Previous to installation, each of the ten KEA AOC 15/50 turbines at Kotzebue was expected to eliminate the need for about 9,000 gallons of the diesel fuel normally used to produce electricity. With a total of 10 turbines and 660 kW capacity installed, the co-op expected to reduce annual fuel use by about 90,000 gallons. That is about 6% of normal fuel requirements.

The installed cost of the wind project in Kotzebue was more than twice the industry standard for a utility scale wind-power plant because of the town's extremely remote location and severe climate. The first three turbines that were erected cost $2,985 per kW to install and commission. KEA estimated that the remaining seven turbines cost between $2200 per kW and $2,500 per kW. The costs of the turbine hardware and installation amounted to 63% of the total for the three turbines purchased in 1997 and 50% for the 7 turbines purchased in 1999. KEA contributed $300,000 towards the wind project, and the balance was covered with grants from U.S. DOE and the Alaska Energy Authority. Based on the average cost of diesel in 1998, the wind project was reported as saving consumers about $86,000 per year; however, KEA still had to raise electricity rates in 2001.[103]

With a total installed cost for 660 kW of $1,745,750, an allowance of 5% for operation, maintenance, and repair, a 13% plant factor, based on actual 1999 operations (755,464 kWh produced), a 20 year life, and 5 3/8% interest rate, the annual cost per kWh is estimated at $.20. Using the local utility estimate that one gallon of fuel can produce 14 kWh, it follows that the utility would need to pay above $2.80 per gallon of diesel in 1998–1999 to favor the use of wind power as a substitute. This $.20 cost per kWh and the fuel cost trade-off at $2.80 per gallon are somewhat understated as they do not include several necessary adjustments:

Inclusion of a remote site outage factor, to compensate for units out of service an extended time, due to site isolation and severe weather, has not been included (use 10% overall).

- Decommissioning of the units (not estimated).
- Adjustment for price level increases since the KEA installation took place prior to 1999, estimated at 11% using the CWI composite index.

[102] 19,700,000kWh in a year and 1,400,000 gallons of diesel = 14 gallons per kWh.

[103] Discussion summarized from International Council for Local Environmental Initiatives accessed at http://www.greenpowergovs.org/wind/Kotzebue%20case%20study.html.

- Decreased fuel efficiency from increased cycling of the marginal diesel units, due to wind variation (possibly up to 50% for the incremental unit).
- Repair technicians and parts will need to be flown in (possibly 2x or 3x repair cost).

These factors could combine to indicate an upper range estimated cost well in excess of $.20 per kWh and a diesel fuel cost trade-off balance point well above $2.80 and perhaps as high as $4.25 per gallon. The above comparison treats the spike in fuel cost caused by international unrest and crude oil flow disruption observed in '03 and '04 as a short-term variation in the context of the 20-year life of the units and 50-year planning period.

There are some practical limits on how much savings can be passed onto rate payers. This is because, for Alaska's small communities involved in the Power Cost Equalization system, on average, fuel makes up only 26% of the cost per kWh.[104] More specifically for AVEC, some three quarters of the system cost is maintenance, labor, insurance, operations, interest, and depreciation, which cannot be eliminated by better generation facilities. For example, AVEC experiences $.275 kWh overall for operation and maintenance and only $0.09 for fuel. Even with zero cost for fuel, electric bills would still need to be high enough to cover the remaining cost. Nevertheless the forward thinking evident in the KEA initiative is a bold and positive measure that needs to be respected for its balancing, and uncounted social and environmental value, as well as its economic promise and technological contribution.

Without continued subsidies (such as grants, low interest loans, partnering, special programs, tax credits, etc.) high saturation wind energy will need to benefit from some form of accompanied cost reduction. Without such incentives and rewards, heavier expectations are likely to be put on the potential for technological change. Without either, development of wind power is going to have to rely on expectations of hard dollar benefits from long-term higher fuel displacement costs to become a viable energy alternative in remote arctic low plant factor locations.

**Fuel Transportation Cost Savings Evaluation Procedure**. The NED economic analysis applies the principles set forward in Corps Guidance, specifically that in ER 1105-2-100. In that regard the analysis provides a framework to capture the transportation cost differences which can be credited to the project by comparing origin to destination cost with a project and without it.

Where there is a change in origin, such as in the case of fuel supply, shifting from the west coast of the U.S. to Singapore, the analysis measures the difference in cost per gallon at the point of origin as one component of the benefit measure. This measure is designed to aid in capturing the difference in the total cost of producing the commodity that would move with and without the plan, because the benefit is the reduction in total cost of producing and of transporting the commodity.

**Project Related Expansion of the Delivery Radius**. In the with-project condition, use of a deep draft tanker will make it possible to buy fuel at less cost from foreign sources, and the deep draft tanker will also reduce overall transportation cost compared to the cost of tug and barge combinations thereby resulting in a lower delivered cost. This with-project delivery scenario is

[104] Sustainable Utilities In Rural Alaska, Colt, Goldsmith and Wiita, Mark Foster and Assoc, 2003, ISER, University of Alaska, accessed at http://www.iser.uaa.alaska.edu/Publications/sustainA.pdf.

compared to a without-project delivery where Kotzebue, Nome, and other villages are all served by higher cost barge operations out of Puget Sound and the Kenai Peninsula.

One affect of this lower delivered cost at Portsite is to significantly expand the radius which can be competitively delivered from Portsite; as a result villages known to be inside of the radius will benefit from the transportation improvement. Two of the larger benefiting communities are Kotzebue and Nome; therefore, the communities, which are satellite to them in the without-project condition, will enjoy a cost reduction in the with-project condition. Portsite becomes a node for delivery to 47 villages most of them being coastal, near coastal, or riverside.

The area served extends over a coastal distance in excess of 1,000 miles, from Kaktovik about 315 miles beyond Barrow, then south beyond the mouth of the Yukon River, and up the Yukon River bisecting the reach below Nenana. The area served would extend beyond this radius except that the boundary is set by an overlap, or contact with the competitive radii, served out of Dutch Harbor, Adak, and the Kenai Peninsula. The benefiting area is only extended to the point where delivery from another supply center can be made at equivalent cost, considering travel cost only.

On the Yukon River, fuel delivery to the upper reach originates on the Tanana River, a tributary to the Yukon above Nenana; the established carrier is Yutana Barge Lines also known as Yukon Fuel Company. In the with-project condition, service provided on the uppermost reach is unlikely to shift away from Tanana, while Yutana or others will be able to provide a lower cost fuel delivery on the river below Galena by operating from Nome.

Some benefits are derived from fuel purchased at lower cost foreign sources and by lower unit cost transportation due to use of larger carriers. In the with-project condition the supply route is from Singapore to Portsite by deep draft tanker, then by large ocean going barge to Kotzebue and Nome, and then to a number of villages designated for direct barge delivery (referred to in the discussion as Village Direct) in the both the with-project and without-project case. After delivery to Nome, Kotzebue, and Portsite, there are many villages served on a final link by a small lighter, and there is air delivery to other destinations.

With the project, there is also an ocean going barge link, which will deliver from Portsite serially to Point Hope, Point Lay, Wainwright, and Barrow. High bulk barges are used for deliveries to, Nome, Kotzebue, Portsite, Point Hope, Point Lay, Wainwright, Barrow, Kaktovik, and Village Direct destinations. Nome and Kotzebue act as regional distribution centers for numerous smaller villages delivered from there with smaller lighters.

For the with-project condition, expansion of the delivery radius was estimated by starting with the fuel purchase saving and then calculating how much travel distance this saving could add to the fuel service area while not driving the price above the without-project condition. This approach leaves the subset destinations typical of the service limit of the without-project condition with a full unit savings. The subset typical of the expanded radius will realize smaller savings as the radius is extended, because the potential savings are eaten up by the transportation cost from Portsite. At the outermost limit, the shippers and customers will be somewhat ambivalent about from where the fuel is sourced because of a near equality of costs among the different source possibilities.

The benefit evaluation in this report recognizes that the Yukon Swing Villages are at the margin, and therefore, the benefit to them has been adjusted to recognize a savings progressively decaying to the limit of the delivery area. For other destinations the decay rate is implicit in the cost comparison which takes into account the distance and type of equipment used for delivery in both the with-project and without-project case.

**Order of the Scenarios**. The discussion first deals with shipping cost to illustrate the without-project condition. As part of the analysis, the cost of deep draft delivery is described (earlier reconstruction based on Corps IWR data) and the cost of ocean delivery using a tug/barge combination is reconstructed. There is also a cost reconstruction for two lighter fleets (coastal and inland) using selected smaller capacity shallower draft equipment.

Following the cost presentation is clarification of the without-project condition with regard to various destinations and routes, including fuel delivery to nodes referred to as: Portsite, Nome, Area Villages, Kotzebue, Swing Villages, the Yukon Swing Villages, Yukon Delta and Lower River, and Village Direct Destinations. The discussion establishes the villages served, shipping routes, equipment variations, and cost.

Throughout, the ocean mode and lighter mode are kept separate for purposes of simplifying the overall cost comparison. This allows separation of the lighter link and deals with its cost in separate calculations as the final leg. The discussion of cost comparison and routing differences are complex due to the many destinations, combinations of equipment, and differences in origin between the with-project and without-project case. As an attempt to partition the discussion, the analysis is presented by destination or a group of destinations with six accompanying themes:

- The type and cost of equipment used on various legs/destinations.
- Changes in route and equipment applications caused by the project.
- Overall cost comparison.
- Destinations and fuel use in the general without-project condition.
- The without-project condition as it relates to specific destinations and routings.
- The with-project condition as it relates to cost reductions.

For purposes of simplification, numbers have been rounded and all distances, speeds, tons and gallons have been presented in consistent units of statute miles, statute miles per hour, short tons, and U.S. gallons respectively.

# 8.0 FUEL DELIVERY: OCEAN TUG AND BARGE OPERATIONS

**The Role of Ocean Tugs and Barges.** Crowley Marine Services is one company that provides tug and barge service as part of their marine service and also operates specialized equipment for fuel transportation. Companies, including Crowley, deliver fuel to Kotzebue from Puget Sound and the Kenai Peninsula, using ocean going barges, and at the destination, offload it to tank storage. After entering storage at a tank farm, fuel is then transferred to end users at outlying villages by use of smaller lightering vessels, some of which are owned by other transportation companies. Crowley has a broad range of oil transportation solutions including a large fleet of 450 ft ocean-going barges, small lightering barges, and tankers, which allows Crowley to operate the largest fleet of petroleum barges on the west coast and in Alaska.

The mainstays of this fleet are the 450 Series barges, with a carrying capacity of 125,000 barrels of product, but these line-haul barges can only get into Portsite with a four million gallon load due to draft constraints. So, the six million gallons of gas and diesel that comes into Kotzebue each summer comes in at three to six different times as part of the process of lightening each barge so it can call at Portsite. The typical Kotzebue fuel scenario, as described by local sources,[105] in an example of one year is: 1st barge, July 2, to offload HF #1 with anticipated off-load time of 1.5 to 3 days (possibly more), depending on weather, equipment capability, and transfer quantity. Crowley uses a similar rule of thumb, allowing for a 2 to 4 day window per million gallons. On July 10, the 2nd barge arrives with gasoline, Jet A, etc., and a 3rd barge is scheduled for late July/early August, loaded primarily with HF #1. This barge will be followed by a 4$^{th}$, 5$^{th}$, and possibly 6$^{th}$ barge to meet all of the regional needs.

**Fleet.** The regional fleet capable of plying the offshore waters and making trips from the Kenai/Anchorage area or Puget Sound is based on vessels which have been known to be active in the region bounded on the North by Point Lay and on the south by Nome which is a straight line distance of about 300 miles with Portsite near the center. The fleet includes about 30 different vessels with 10 different owners, most of them ocean going barges and their tugs. The number of vessels and the specific vessels that make up the fleet change from year to year as vessels cycle in and out. At the time of this writing, the deepest vessel combination is the tug and barge combination, Vigilant/416, which drafts over 18 ft, and the deepest barge is a Crowley 450 of about 20 ft draft. The shallowest ocean going barge is the Redoubt, which drafts just under 7 feet.

[105] Based on pre-season plans for the Year 2002 season as explained by Tom Bohlen NWAB.

**Table 53. Fuel And General Cargo Ocean Barge Fleet Excludes Equipment Dedicated To Portsite**

| Vessel | Draft (ft) | LOA (ft) |
|---|---|---|
| Nana Provider | 14 | 340 |
| Seneca/250-10 | 12 | 247 |
| Crowley 450 Series | 20 | 400 |
| Sea Vixen/Malol | 14 | 395 |
| Vigilant/416 | 19 | 395 |
| Mercury/250-6 | 12 | 247 |
| Bulwark/450-7 | 17 | 395 |
| Bulwark/101 | 17 | 296 |
| Baranof Trader | 12 | 227 |
| Drew Foss/Naknek | 10 | 283 |
| M O'Leary/Kvic | 10 | 247 |
| P Challenger/3 | 18 | 326 |
| P Challenger/1 | 18 | 178 |
| World Discoverer | 18 | 281 |
| Double Eagle/24 | 11 | 237 |
| Redoubt | 7 | 158 |
| Amatull | 14 | 112 |
| Muir Milach | 10 | 84 |
| Arctic Bear/Pro | 12 | 247 |
| Arctic Star | 15 | 262 |
| Impala | 10 | 163 |
| Croatian Turn | 8 | 64 |

There has been interest in introducing integrated tug/barge units using a 420 ft barge into which a 149 ft tug would tuck about 50 ft of its length. This would create an integrated unit with about 520 ft overall length. When dock side, or at anchor, the combination could be separated leaving a 420 ft barge. This type of equipment is ordinarily used on long hauls with high capacity and with short turn around times (total cargo transfer inside of 24 hours), untypical of Kotzebue or other Kotzebue Sound, Norton Sound, or Bering Sea ports. When fully loaded, the unit would carry 180,000 barrels and draft 33 ft. With its 20,000–30,000 ton displacement, it is comparable to a small tanker ship. Economic advantages of its use at Kotzebue or Portsite would be difficult to justify unless Portsite were to be modified for direct unloading of deep draft equipment.

The main vessel of interest in this discussion is the tug and barge combination most likely to be used for long range delivery of fuel from Puget Sound to Portsite and Kotzebue. This is because, in the with-project condition, this origin-destination pair is shifted to Singapore–Portsite; the tug/barge combination is replaced with a deep draft tanker. It is therefore important to identify the typical or preferred tug and barge combination in order to reconstruct the economic cost of shipping which could eventually be reduced by the project. The selected combination is a 450 series tank barge and a Sea-Victory class tug of from 6,000 up to 10,000 HP.

Tugs of the 10,000 HP size have been selected to operate as tanker escort vessels in Alaska waters, and two new tugs were recently built specifically for that purpose. The tug would be twin screw and designed for heavy weather ocean towing with multiple winches and control stations but does not need to be of the tractor design, because it will function as a line-haul tug. The barge, presumed to be in use for this long distance delivery, is able to transport about 148,300 barrels, about 6,228,600 gallons according to the United States Coast Guard (USCG) worst case spill scenario but is generally loaded with 125,000 barrels, about 5,250,000[106] gallons, equivalent to a dwst capacity of 17,850 st. There are smaller tug and barge combinations in use, such as tugs in the Sea Robin class (up to 5,000 HP), coupled with 200, 360, or 400 series barges (ranging from 7,999–12,000 tons). The smaller combinations are in use for petroleum delivery in western Alaska, but the barge capacity is less by about 30%, and this would require three added trips for service to Kotzebue and Portsite. The hourly cost savings of using the smaller Sea Robin class combination is more than offset by increased cost of the added trips; the increased risk of greater exposure thus making the larger combination a preferred choice.

**Cost.** Unlike other barge and tug equipment discussed in this report, the fuel handling equipment is not dedicated to Portsite or any other particular operation and is assumed to be busy year around to the extent that opportunities for gainful employment are presented. This is supported by the fact that, regarding deliveries to western Alaska, there is no exclusive fleet arrangement, specialized equipment, or unusual personnel requirements, and the equipment is adaptable for use world wide. A combination of standard Corps' and industry sources, and site specific information were used to reconstruct cost of the tug which has a horsepower rating comparable to the larger line-haul equipment operating on the Mississippi and inland system. The fuel barge, however, is unlike anything listed in the standard tug and barge sources so was estimated by reducing the cost of a listed[107] 297 ft x 54 ft x 12 ft, 3,325 ton capacity, double hull tank barge with coils, to a cost per ton and then expanding it to 17,850 swt using a factor of 5.4.

Fuel cost is deserving of an explanation prior to presenting the various equipment operating costs. The fuel savings benefits are linked to using Singapore as the purchase point and this saves $.15 per gallon while using a deep draft tanker accounts for another $.06 = $.21 per gallon saving, but there are other intermediate costs to account for such as lightering.

One component of the cost of lightering is the cost of fuel for the tugs which is based on a constant $1.40 per gallon for the without-project condition and the with-project condition. The $1.40 is based on actual reported fuel cost for fishers and tugs operating out of other ports in western Alaska, and it includes delivery, storage, reselling cost, and Corps' cost estimating location factors consistent with pre-Iraq war market dynamics.

In 1998, marine fuel costs at Bering Sea locations were about $1.00 gal for purchases of 600 gallons, and since have increased by almost 40% to an average value of $1.40 at other western Alaska ports. This is also verified though the PFMC EIN database.[108] The $1.40 applies to all tugs and barges and lighters, because some will be in route to jobs elsewhere and will fuel at multiple locations during the course of the season.

The dedicated tug and barge fleet is supplied with fuel brought with them from Seattle through a special rate structure meshed with a bundle of other services. This fuel is transported aboard tanks built into the self-unloading barges which are moved to Portsite with tugs at the beginning of each season. In contrast to documented market prices, a financial agreement between TCAK and Crowley has had fuel purchased for use at the mine at $1.01 per gallon. This is negotiated

[106] Design fuel barge in AGRA Project A151H Report, 12/29/2000, Section 6, page 2.

[107] Corps of Engineers Economics Guidance Memorandum.

[108] See, West Coast and Alaska Marine Fuel Prices, Economic fisheries Information Network, Pacific States Marine fisheries Commission.

within a bundled rate structure that does not add the cost of freight, or the cost of fuel transfer, storage, or reselling. In the analysis of reconstructed cost, fuel for the dedicated tug and barge fleet is accounted for at an opportunity cost rate equivalent to $1.40/gal.

In this NED analysis $1.40 represents the opportunity cost of fuel (what the market indicates would have to be given up to get it) and is used throughout the benefit evaluation for all of the alternatives. In the Sensitivity Analysis section of this Appendix the economics of the recommended plan is also tested using a financial cost of fuel, ranging from $1.07 to $1.58 per gallon. The range in fuel cost leads to a change in benefits associated with tug and barge cost of about–8 to+4%. These benefits make up about 41% of the benefits of the recommended plan so the total benefits of the recommended plan are reduced by about 3% or increased by 1% when the financial cost of fuel is used as a substitute.

All of the equipment costs presented herein rely on the $1.40 per gallon fuel cost; the cost is not changed between the without-project and with-project condition, because the cost difference is accounted for separately elsewhere in the benefit calculation. Specifically, one component of the benefit is a savings in delivered cost of all gallons to Portsite, and this includes all gallons delivered by water to the affected destinations.

Also worthy of discussion is the reason for setting the economic life of the ocean line-haul equipment at 25-years in contrast to reasons for setting the life of harbor tugs at a 25-year life. Some data shows a basis for differences between harbor equipment and ocean use equipment with many data sources indicating that the life of harbor tugs is actually in excess of 25 years. In this report, the 25-year estimate is specific to the fleet in use at Portsite and is documented by a marine survey done in connection with assessing the quality and suitability of the equipment for the use arrangements at the site.

Available data indicates there are many tugs currently in service that are 30, 40, 50, 60 years, and older. Looking at the market for used tugs, one can see from Marcon International Corporation data that, in April 2003 of the 2,480 tugs that Marcon tracks, there are 554 currently on the market for sale worldwide. Of these 554 tugs, 132 of the tugs worldwide were built within the last ten years, while 75 of them are over 50 years of age, eleven tugs are 75 years of age or older, and 29 have no age listed. Currently the oldest tug listed for sale is a single screw Danish, 60 ft x 14 ft tug, built in 1908 by Wilhelmsbergs MV in Sweden and powered with a single CAT diesel.

Following is a breakdown of the listed available anchor handling coastal, ocean and harbor tugs. Separate reports are available on inland river pushboats and anchor handling tug supply vessels.

**Table 54. Number Of Tugs By Horsepower**

| | Under 1000 | 1000 2000 | 2000 3000 | 3000 4000 | 4000 5000 | 5000 6000 | 6000 7000 | 7000 8000 | 8000 9000 | 9000 plus | Unk. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| April 2003 Worldwide | 137 | 180 | 94 | 72 | 37 | 21 | 2 | 3 | 6 | 2 | - | 554 |
| April 2003 U.S. | 44 | 49 | 20 | 22 | 10 | 5 | - | - | 3 | 1 | - | 154 |
| April 2003 Foreign | 93 | 131 | 74 | 50 | 27 | 16 | 2 | 3 | 3 | 1 | - | 400 |
| Avg. Age Worldwide | 1969 | 1970 | 1978 | 1978 | 1982 | 1984 | 1984 | 1984 | 1979 | 1980 | - | |
| Avg. Age U.S. | 1964 | 1952 | 1962 | 1966 | 1968 | 1982 | - | - | 1980 | 1981 | - | |
| Avg. Age Foreign | 1971 | 1978 | 1982 | 1983 | 1987 | 1984 | 1984 | 1984 | 1984 | 1978 | - | |

Looking at the 3000–4000 HP class, the average age of U.S. vessels in the 72 vessel sample is 37 years. Building of tugs virtually ceased especially in the U.S., dropping from 47 in 1978 to 7 in 1984. As of July 1998, the average age of U.S. anchor handling tugs was 23.6 years. This makes the U.S. fleet one of the oldest in the world. It is concluded that the fleet average life expectancy may be somewhat in excess of the 20-years applied in the Corps' EGM database. The only reliable means of estimating the remaining economic life of specific pieces of equipment in service at the Delong Mountain Terminal is to employ the assistance of a marine surveyor, which was done in this case, and which provides specific support to the 25 year economic life used in the Economics Appendix.

In a related review of tugs (reached their limit of useful life in 2002), it was found that as the fleet ages to about 25 years, owners, especially in the U.S., are refurbishing instead of building new. For example, Crowley launched a major refurbishment of 25 sea-going, 7,200 HP Invader class tugs to extend their lives 15 additional years; these tugs were all built between 1974 and 1977 by McDermott Shipyards. This group of 25 tugs had lived out their average economic life of 25 years, which provided additional support for using 25 years for anchor handling harbor tugs in this report. In cases such as this, the tugs are made more modern and more economical for their intended use as a remedy to problems of technical obsolescence, but the technical obsolescence was indicated at age 25.

The economic life tables (Corps' EP 1110-1-8, dated 31 August 2001) list tug life expectancy in 1,000 HP intervals with a life expectancy of 25 years for tugs rated over 3,000 HP, the largest class shown. There is no data for ocean line-haul tugs of 10,000 HP.

**Table 55. Annualized Life Cycle Cost Ocean Tug And Barge Operation**

| Item | 10,000 HP | Barge |
|---|---|---|
| Cost[109] | $11,922,400 | $8,211,000 |
| Life | 25 | 25 |
| Salvage[110] | $3,850,000 | $507,000 |
| PW replacement, year 25 | $2,180,500 | $2,081,000 |
| Net PW | $14,102,900 | $10,292,000 |
| 50-Year A&I | $817,700 | $596,700 |
| Labor Cost[111] | $2,400,000 | nil |
| Management | $84,000 | $37,400 |
| Non-labor operating, repair, maint, supplies[112] | $5,358,000 | $562,800 |
| Insurance | $110,000 | $82,000 |
| Transportation[113] | $60,200 | |
| Subsistence [113] | $135,800 | |
| HQ Administration | $977,800 | $81,900 |
| Profit @ 10% | $896,500 | $136,100 |
| Annual Cost | $9,943,500 | $1,496,700 |
| Annual Hours[114] | 8,400 | 8,400 |
| Hourly Cost | $1,184 | $178 |

This report uses an ocean tug-barge combination cost of $1,362/hour which is about 37% higher than the cost of a 6,000 HP unit but provides a slightly higher speed under most conditions, thus compensating somewhat for the higher hourly cost. The more powerful unit also provides a comfortable safety margin, an important factor in fuel hauling.

[109] Derived from comparable market sales reduced to unit values.

[110] Based on tugs on the market in 2001 with an age of 30 years reduced to cost per horsepower. Salvage value of the barge is arrived at by establishing a scrap value of $145/ton for hulls from the vessel scrap market and an estimated light displacement of 3,500 tons.

[111] Borrowed from calculations for the dedicated fleet and adjusted as an average hourly cost over a year.

[112] EP1110-1-8, a/us army Corps of Engineers publication.

[113] Industry data source with disclosure limits.

[114] Based on 350 operating days at 24 hours per.

# 9.0 FUEL DELIVERY: COASTAL LIGHTER OPERATIONS

**Role of Coastal Lighters.** Lighter is a general name for a broad, flat-bottomed boat, used in transporting cargo between a vessel and the shore; the distinction between a lighter and a barge is that some lighters are self-powered, while others require the use of a tug. The term "lighter" refers to a short haul trip, generally in connection with loading and unloading operations of vessels in a harbor, while the term "barge" is more often used when the cargo is being carried to its destination over a long distance. Lighter is also used as verb meaning to load or discharge cargo to or from another vessel.

The concept of lighters is important to this analysis, because they are prominent in the regional transportation system in both the with-project and without-project condition, although they are used somewhat differently in the two cases in that there is a shift of intermediate routing serving origin and destination pairs. The shift in routing increases the cost of some lighter routes while decreasing the cost of others, a matter that is taken into consideration in deriving the overall origin to destination cost of the with-project and without-project condition and which presents notable complications in the presentation of the comparative costs.

Ideally, village residents would elect to use water transportation at every opportunity, because it promises to be the cheapest delivery mode, and since most of the villages served from Kotzebue are located directly on the beach, water transportation has the advantage of being the least complex. The major disadvantage is that goods shipped by water must be delivered first to Kotzebue or Nome where they are re-shipped to the final destination. Delivery to Kotzebue requires assembling cargo into barge size lots at Seattle or Anchorage and arranging it in a manner that it can be off-loaded to a smaller shallower draft barge, 15 miles out to sea from Kotzebue. The shallower draft lighters deliver the cargo to Kotzebue where re-shipping takes place. This involves delivery to land-based staging areas at Kotzebue where the cargo undergoes a make-break operation to re-sort shipments into units for delivery to a final destination. Sorting the cargo at Kotzebue involves several pieces of machinery, temporary storage areas, and a number of personnel. It is a necessary operation to minimize time, confusion, risk, and breakage when the lighter making the final delivery beaches itself to unload at the village destination. Fuel delivery is changed in the with-project condition while the general cargo delivery scenario is unchanged in the sense general cargo will continue to be shipped in the conventional fashion. Portsite development options do not provide any savings to shippers of general cargo.

Fuel delivery through Nome is less complicated, because there is a causeway dock, deep enough to accommodate the large barges, and negating the need for lighters during delivery there. Lighters are still required for the link to villages delivered from Nome.

Some of the fuel lighter fleet in the region functions in a limited dual purpose role in that they can carry also carry a small load of low density deck cargo; however, the carrying capacity of these lighters is ordinarily quite small, and they function in this manner with or without proposed improvements. A typical lighter would be capable of carrying about 200–500 tons of fuel. In comparison an ocean barge could carry 12,000–17,850 tons.

There are other concerns with the need to undergo a transfer operation to move cargo from the ocean going barge to the lighter and then to Kotzebue. Movement to the lighter is followed by storage at the harbor while the cargo or fuel awaits arrival of a second lighter for the trip to a final village destination. Ideally, the lighters schedule themselves to be available when the barge arrives off of Kotzebue to minimize interim storage and re-handling, and in the past, some lighters have been hauled in with the ocean barge while others may be kept on station permanently. If a lighter is hauled on deck to the off-shore anchor point, it is lowered into the water to serve as part of the local lighter fleet. The locally used lighter is not necessarily owned by Crowley although a Crowley subsidiary, Arctic Lighterage, has two small tug/barge combinations that are kept at Kotzebue specifically for lighter service to Kotzebue and area villages.

Sometimes lighters are delayed due to sea conditions that keep them from prompt arrival, and in other instances, rough conditions at sea have interfered with cargo transfer. Weather delays can cause the tug and barge to incur non-productive time and can also cause waiting of the crews, waiting of the lighter, delay at the village destination, and waiting for final delivery by the end user.

Motivation for performing the transferring operation at Kotzebue is that it is speedier to do it at a location where modern handling equipment is available and a storage area is available in the event schedules are delayed or weather changes for the worse. Working from a load center is also a way of achieving economies of scale for the overall operation.

Throughout speed is of the essence, because deliveries, late in the season, run the risk of being delayed by weather while ice is forming at the delivery destination or along the main sea route. In freeze-out events two choices are available to village residents; they can go without, or they can use air freight.

To the village residents, the option, if going without, creates hardships they can avoid only by delivering cargo and fuel by air. Goods which are shipped from Seattle are often late being delivered to Kotzebue because of weather conditions especially in the late summer. As the seasons began to change, fall leads into serious storm conditions. It is at this time of year that vessel delays begin to be a serious worry because sooner or later the ocean will freeze over for the winter.

There are generally understood threshold conditions which operators prefer not to risk if they are not compelled to do so. Some of the events, which cause delays for the off-loading of barges onto lighters, are steep waves which can make the vessels shift during the transferring operation, and following seas which can cause the lighters to broach approaching the shore. They become more likely as winter nears.

Lighters can be single vessels or combinations of tugs and barges up to 149 ft; many of them are draft limited, in the sense, they often will not load to their maximum draft because of depth limitations at their destinations or because they may not have adequate cargo to load them fully to capacity on some legs of their trips. Lighters are most fully loaded when leaving Kotzebue or Nome. At each destination, the lighters drop off some cargo and generally return empty.

The required operating depth for various vessels in the lighter fleet can be somewhat misleading, because some of the lighters are equipped with a bow ramp and are designed to be landed with the bow on the beach. Even though some of these vessels may be beached at the bow, it is essential for some that appropriate operating clearance is maintained under the rest of the vessel to avoid damage to rudders, shafts, cooling systems, and props. The lighters accommodate the need to operate in shoal conditions by light loading which is the rule rather than the exception.

**Coastal Fleet**. The coastal lighter fleet consists of a share of the commercial transportation vessels that are active in the region between Nome and Point Lay. These commercial transportation vessels are in addition to the deeper draft, off-shore equipment previously listed. They differ in that they are considerably smaller and designed to operate in near-shore shallow waters and draft under 7.5 ft fully loaded. They are smaller tugs, matched with smaller barges and self powered lighters.

**Table 56. Coastal Lighter Fleet**

| Name | LOA | Design | Design Draft |
|---|---|---|---|
| Sam Talak | 149 | Landing Craft (LC) | 6 |
| Quyaq | 185 | Barge | 7.5 |
| Greta Akpik | 147 | LC | 8 |
| Unnamed | 146 | Barge | 7.5 |
| Nunaniq | 146 | Motor Vessel (MV) | 7.5 |
| Kuparuk River | 100 | Tug | 6.8 |
| | 150 | Barge | 7.5 |
| BC151 | 150 | Barge | 7.5 |
| 160-1 | 79 | Barge | 7.5 |
| Kavik | 74 | Tug | 7.5 |
| St. Michael | 73 | MV | 7.5 |
| Siku | 73 | Tug | 7.5 |
| Sinuk | 71 | Tug | 7.5 |
| Sadie Brower | 67 | MV | 7.5 |
| Postouk | 63 | LC | 3.5 |

**Cost**. The cost basis used to estimate cost of delivery by water is based on a combination of sources and techniques including an inventory of the lighter fleet and an examination of comparable vessel sales data plus standard Corps' cost estimating applications of EP 1110-1-8 and information on actual cost.

One of the comparable vessels is described as 162 ft x 38 ft x 6.8 ft and is a heavily built Landing Craft constructed in Japan for a Canadian oil company for use in the arctic. The subject vessel was fitted around 1999–2000 with two new hydraulic retractable drives/props driven by 1,000 HP and is equipped with a deck crane and is rated exceptional overall. Slightly larger than most of the coastal lighters known to be in use, at full design draft, it has the capacity to carry 740 tons of cargo on deck or 745 tons of fuel oil, in tanks below deck, and can pump against a 50 ft head at 200 gallons per minute.

Because of the preponderance of shallow water operating problems in the area, the fleet in use generally limits its loads to 5.5 ft draft, about half of the certified load of the vessel used for gathering comparable data. The open deck space is 100 ft x 40 ft sheathed in pine, and it has a bow mounted ramp 20 ft wide x 30 ft long, and its speed is reported to be about 8–10 mph, consuming 1 gallon per horsepower per day. It has 4 longitudinal and 5 transverse bulkheads, a crew of 6, and has 3 single berth and 2 double berth cabins. After adjustments for power and age, the value is estimated at $1,556,000.

**Table 57. Coastal Lighter Operating Cost Vessel Length 162 ft Powered By Diesel With+1500 HP, Two Or Three Screws Or Matched Tug/Barge Combination**

| Reconstructed Item | 1,500 HP Lighter |
|---|---|
| Cost[115] | $1,556,000 |
| Life[116] | 20 |
| Salvage | $577,500 |
| PW replacement, year 20 | $343,400 |
| PW replacement, year 40 | $120,500 |
| Net PW | $2,019,900 |
| 50-Year A&I | $117,100 |
| Labor Cost[117] | $614,200 |
| Management | $62,400 |
| Non-labor operating cost | $236,800 |
| Subsistence | $6,700 |
| Transportation | $15,400 |
| Insurance | $31,200 |
| Sub Total | $1,083,800 |
| Administration | $116,000 |
| Profit | 119,900 |
| Total Annual Cost[118] | $1,319,700 |
| Annual Hours | 2,568 |
| Hourly Cost @ 8–10 mph | $557 |

In addition to self powered lighters, there are several tug/barge combinations available. The tug and barge combinations, in use, are owned by Crowley Marine, and according to company web page data, there are four 5,000 series Sea Robin class tugs, used for towing oil barges in western Alaska. The typical vessel is equipped with dual winches and a raised forecastle, and the cost of a combination tug and oil barge in serviceable condition would compare favorable with the above. For short distance lighter operations, barge capacity in the Kotzebue area is ordinarily in the 500 ton range, due to draft limitations. A typical vessel would be certified for a fuel load of 200,000 gallons or 680 tons, and the largest application could carry 740 tons; however, this would probably be at a draft too deep to be practical. In contrast to the coastal lightering equipment, the typical ocean oil barge is a 400 series, and such barges, in use, for long distance delivery are able to transport about 5,250,000 gallons with a dwst capacity of 17,850 tons.

[115] Marcon International data reduced to cost per HP.

[116] Beaching, shallow operations, remote location, unimproved ports cause high wear and tear and excessively high repair cost resulting in shortened life. Agrees with EGM data.

[117] Borrowed from calculations for dedicated fleet.

[118] Based on 112 day ocean water season adjusted down to 107 days to allow for fresh water lighter delivery routes becoming impassable sooner than Kotzebue Sound, and the Bering Straits.

# 10.0 FUEL DELIVERY: INLAND LIGHTER OPERATIONS

**Fleet.** The inland lighter fleet consists of a share of the commercial transportation vessels that have been known to be available for use on the lower Yukon River, generally below Nenana. These commercial transportation vessels are in addition to the deeper draft, off-shore equipment and higher powered coastal equipment previously listed. They differ in that they are considerably smaller and designed to operate in shallow river waters and draft under 5.5 ft fully loaded. They are smaller tugs matched with small barges and small scale, self-powered lighters listed below. Barges are not shown because the tugs can be matched with a variety of sizes and multiple barge configurations. They are accompanied by a separate cost estimate, because the river lighter fleet also enters the benefit evaluation. Some of river origins are changed between the with-project and without-project condition. The cost is based on estimates for the coastal lighters with an adjustment for installed HP, which is typically in the 800–1,000 HP range.

**Table 58. Inland Lighter Fleet: Lower Yukon**

| Name | LOA (ft) | Design | Design Draft (ft) |
|---|---|---|---|
| Akiak | 52 | Inland Tug | 3 |
| Chena | 47 | Inland tug | 3 .2 |
| Rampart | 70 | Inland tug | 3.25 |
| Kantishna | 54 | Inland Tug | 3.25 |
| Tanana | 120 | Inland Tug | 3.25 |
| Coastal Marine | 58 | Coastal/Inland Tug | 4.5 |
| Jackie M | 68 | Coastal/Inland LC | 5.5 |
| Noatak | 80 | Coastal/inland Tug | 4.5 |
| Twi-lite | 85 | Coastal/Inland LC | 5.5 |
| Pastolik | 73 | Inland/Coastal Tug | 4 |

Other inland/coastal lighters actively used in western Alaska include Anvik, Captain Atkins, Cross Point, Morning Thunder, Mutt, Noatak, Seven C's, St., Michael, Sundowner, and Yamhill.

**Cost.** Two recent additions to the fleet are a 900 HP, 4.5 ft draft tug, formerly the property of Coastal Marine, and a newly configured tandem landing craft. The landing craft is made of two older hulls welded together, each retaining its original drive and steering, but operated through a centralized control unit. Operating cost is nearly equal between the two vessels, and only the tug-barge combination operating cost is shown as typical of the inland fleet.

**Table 59. Inland Lighter Operating Cost Vessel Length 60 ft Powered By Diesel With 800 HP, Articulated Drive Two Screw, Tug/Barge Combination**

| Reconstructed Cost Item | 800 HP Lighter |
|---|---|
| Cost | $600,000 |
| Life | 20 yr |
| Salvage | $228,000 |
| PW replacement, year 20 | $130,600 |
| PW replacement, year 40 | $45,800 |
| Net PW | $776,400 |
| 50-Year A&I | $45,000 |
| Labor Cost | $614,200 |
| Management | $62,400 |
| Non-labor operating cost | $125,500 |
| Subsistence | $6,700 |
| Transportation | $15,400 |
| Insurance | $11,900 |
| Sub Total | $881,100 |
| Administration | $105,700 |
| Profit | $65,700 |
| Annual Cost | $1,052,500 |
| Annual Hours | 2,568 |
| Hourly Cost @ 8–10 mph | $410 |

As a reality check the above reconstructed cost was checked against publicly available vessel cost data. Yukon Fuel files public rate data and also notes an incremental hourly cost for delay of units at $400 per hour.

# 11.0 FUEL DELIVERY: AIR COST AND RADIUS

**Air Delivery Radius**. There is a need to assess the air delivery radius under with-project and without-project conditions to determine whether the reduction in fuel purchase cost will materially affect the radius delivered by air and hence add market volume to the with-project condition. The potential impact of lower fuel cost on air delivery radius was estimated by developing a case study, based on deliveries to the upper Kobuk River villages out of Kotzebue and Fairbanks.

**Destinations**. In the Kotzebue area, in a typical year, up to 750,000 gallons, or 2,550 tons is delivered to regional villages by air, some out of Kotzebue and some from Fairbanks. It is common for villages on the Kobuk River to be delivered periodically by air because of low river levels that prohibit water delivery except early in the season. It is typical, during upper Kobuk deliveries, for the plane to originate from Fairbanks and return there for successive loads. The distance from Fairbanks to Kobuk/Shungnak area is greater than from those villages to Kotzebue; however, the cost of fuel in Fairbanks is much less expensive than at Kotzebue.

For air deliveries to Noatak, Kiana, or Buckland (the latter two have historically ordered air deliveries when they run out of fuel during the course of a winter, and Noatak, in recent years, gets all delivery by air due to navigation channel shoaling), the plane would originate from Fairbanks but would re-fuel for successive trips in Kotzebue in the event that more than one trip is required. For successive trips the distance back to Fairbanks out weighs the saving in the fuel cost.

Smaller orders are delivered by air directly from Kotzebue when villages are in danger of running low during the winter. Such emergency supply is important to the health and safety of the village residents, but in the overall scale of regional transportation costs, emergency supply is a small part of Portsite economics, and in the context of this report, emergency air supply will persist with the project or without it.

**Cost**. The air service radius, served from Fairbanks and Kotzebue, will not shift appreciably because of cost and service limitations of the type of aircraft used. The aircraft must be capable of short field performance, and typically, a single engine DeHavilland, or a Twin Otter, or Turboprop Cessna Caravan are employed, which are all capable of carrying a fuel payload of 600–1000 gallons or less. At a difference in fuel purchase cost with the project and without it of $.15, economics of the fuel load would allow the air service radius to be expanded by a distance equivalent of up to $150 air time while not exceeding the delivered cost of the without-project condition. With a cost per statute mile of about $4,[119] the round trip service radius is increased by only about 20 miles and this is not adequate to add any new customers.

It has been suggested that larger aircraft could be used in the event airfield conditions were suitable; however, substituting a C-130 aircraft does not change the economics. Although the C-130 aircraft is capable of a maximum cabin load of 35,000 lbs (about 5,150 gallons) the cost per

[119] Web site access to http://planequest.com/operationcosts/op_cost_info.asp?id=15. Used as a source for comparison of aircraft operating cost.

hour is $3,381.[120] At $.15 per gallon the fuel cost savings is adequate to increase the C-130 flying time by about 12 minutes, which is equivalent to a round trip radius of about 25 miles.

**Table 60. Aircraft Operating Cost**

| Cost Item | Dehavilland | Caravan |
|---|---|---|
| Fuel in Gallons/Hour | 70 | 55 |
| Fuel cost at Kotzebue | $3.28[121] | $3.28 |
| Fuel Cost/Hour | $230 | $180 |
| Oil Cost/Hour | $1 | $1 |
| Maintenance/Hour | $65 | $30 |
| Engine Reserve/Hour | $100 | $100 |
| Prop Reserve/Hour | $10 | $10 |
| Total Variable/Hour | $406 | $321 |
| Average Speed mph | 170 | 155 |
| Cost/Statute Mile | $2.39 | $2.07 |
| Insurance | $11,000 | $11,000 |
| Hanger | $8,400 | $8,400 |
| Training | $7,000 | $5,000 |
| Capital[122] | $52,200 | $52,200 |
| Pilot/Overhead | $60,000 | $60,000 |
| Total Fixed | $138,600 | $136,600 |
| Hours/Year | 500 | 500 |
| Fixed/Hour | $277 | $273 |
| Total/Hour | $683 | $600 |
| Total/Statute Mile | $4.02 | $3.83 |

[120] C-130 data and cost comparisons from http://wizard.ucr.edu/~bkaplan/alcf/acftdata.html.

[121] Data from local FBO, Ralph Wein Memorial Airport FBO website updated 22 June 2001, accessed at http://www.airnav.com/airport/PAOT. Other FBO prices within a 200 mile radius ranged from $2.60–HWi$3.49.

[122] Opportunity cost of capital with an estimated investment of $900,000 valued at 5.375%.

# 12.0 FUEL DELIVERY WITHOUT-PROJECT ROUTE AND COST

**Without–Project Delivery to Portsite**. The marine shipping season lasts up to about 112 days, from early July to early October, when the Bering Strait, Kotzebue Sound, and Chukchi Sea are ice-free. During this period all water borne deliveries to Portsite and area villages are made by barge. The major shipment, coming into Portsite, is fuel to run the port and the mine. Given the current target production level of 1,544,000 swt of concentrate and the present port configuration, 22,357,000 gallons of fuel will be consumed each year, about 14.48 gallons per ton of concentrate,[123] or a total of 76,000 tons. This pattern will remain in effect as long as the production level is maintained at the existing ore grades. When ore grade changes about 2011, mining and milling will need to increase about 10%, if tonnage shipped is to remain at 1,544,000 swt. Additional mining and milling will contribute to an increase in fuel requirements estimated to total 25,712,500 gallons or 87,420 tons. At a potential but unlikely increase in concentrate shipping to 1,729,000 swt, fuel use at Red Dog could increase by 30% to an estimated 29,064,100 gallons or 98,800 tons.

The without-project tug and barge fleet will be replaced with two 4,000 HP tugs fueled at Portsite during the season. Tugs of this size carry 92,000 gallons of fuel, which is adequate to power them to and from Portsite. They will top off once during the season and represent a potential 101,400 gallon demand for Portsite fuel, based on 690 assist hours during the season. The trestle-channel project also includes generation efficiency which results in a reduced fuel demand per kWh. Countering this savings is an addition of mechanical equipment related to the new conveyor and its loading activities which increases electricity requirements. Overall the net result is to add a fuel requirement of 208,900 gallons over the without-project condition. Therefore, fuel requirements for the mine in the with-project condition are 25,921,400 gallons (88,132 tons) at a production level of 1,544,000 swt annually.

The Portsite facility is about 17–20 feet deep at the barge dock so fuel deliveries are made using very large barges which call first at Kotzebue then stop at Portsite. At Kotzebue they offload about 1,250,000 gallons per trip leaving 4,000,000 gallons for delivery to Portsite. At Kotzebue they must anchor 15 miles out to be unloaded due to river sediments deposited by the Noatak River 4 miles above Kotzebue; this deposition of sediment causes the harbor at Kotzebue to be too shallow for the barges, thus requiring cargo to be lightered to shore and warehoused. When fully loaded, the barges also draft too deep to dock at Portsite. Whether light loaded or fully loaded, the call at Kotzebue requires them to anchor offshore. Crowley Marine Services and others operate shallow draft barges to deliver fuel and other cargo from Kotzebue to area communities.

**Without-Project Fuel Delivery to Nome and Satellite Villages**. Annual fuel imports to Nome vary from 8,000,000 to 11,000,000 gallons with all of it being delivered by barge from Puget Sound or the Kenai Peninsula. During the 1990 to 1996 period, annual tonnage through Nome harbor averaged 51,070 tons which included 22,100 tons of non-fuel cargo and 28,970 tons of fuel. The amount of fuel, shipped into Nome and reshipped to villages, has varied from year to year, and over three recent consecutive years, had a mean value of 32,000 tons (10,000,000

[123] Calculated from mine records of actual tonnage shipped in 2001 and actual fuel used. Fuel conversion applied a specific gravity of .81, 6.8 lb/gallon, and 294 gallons per ton. This represents a balance of gas oil and kerosene.

gallons) delivered to Nome and 5,100 tons (1,400,000 gallons) redistributed. The annual variation in deliveries is explained in three ways:

- If a lighter intercepts or accompanies the large line-haul barges that deliver fuel, then the barge off-loads at each village, eliminating the need to transfer fuel through the tank farm at Nome.
- Orders depend on ability to pay.
- Annual delivery fluctuates due to weather and carryover from the prior year.
- The line-haul shipments or lighter connections are delayed and arrive so late that the village delivery cannot be made by water before freeze-up.
- Air transportation is used in anticipation of delivery problems due to weather or equipment situations.

For this economic study, 10,000,000 gallons has been selected as a most likely mid-range estimate typical of the expected future annual delivery into Nome. There is little overall prospect for significant growth in fuel consumption at Nome or the villages served from it, because any demand growth related to population increase is anticipated to be minimized by increased efficiency of fuel use applications and conservation. There are no known or anticipated structural changes in the economic base which would bring about new industrial demands. The amount of fuel that is reshipped by water to Nome area villages is about 1,400,000 gallons per year with emergency airlifts to various villages adding to that amount.

The cost of fuel delivery to Nome is based on shipping by barge from Puget Sound and the Kenai Peninsula. At Nome a large barge will allow the entire shipment to be delivered in two calls with one load from Puget Sound to arrive at Nome in late June or early July. The second delivery is made by filling the barge near Kenai, and at the end of the season, returning the barge to Puget Sound. Voyage lengths are 1,500 miles from Kenai to Nome and 2,150 from Puget Sound to Nome. Total season miles would be:

| Puget Sound to Nome, 2,150 one time | 2,150 |
|---|---|
| Empty backhaul Nome to Kenai | 1,500 |
| Kenai to Nome, 1,500 | 1,500 |
| Return to Puget Sound | 2,150 |
| Total season miles | 7,300 |

Total trips miles for a season would be up to 7,300. It could be argued that the return trip to Puget Sound need not be included, because after the second delivery, the tug and barge are open to other hires. However, using 7,300 miles, at an average speed of 10 statute miles per hour, accumulated travel time would be 730 hours. Using the $1,362 hourly cost calculated elsewhere ($1,184 for the tug and $178 for the barge = $1,362) and a travel time of 730 hours, the travel cost is **$994,300**. In addition to the travel cost, the units will incur some 29 hours time while being unloaded at dockside at a cost of $1,044 per hour = **$30,300**. Unloading is at a protected site so will be at maximum transfer rates. Tug fuel use was reduced by 50%. Total cost is **$1,024,600**.

As a regional transportation center, Nome also serves as a hub for general cargo to satellite villages. Fuel shipments are taken to villages by specialized fuel barges that can run a route and deliver several villages in series. Villages served out of Nome in the without-project condition include Brevig Mission, Deering, Diomede, Elim, Gambell, Golovin, Koyuk, St. Michael, Savoonga, Shaktoolik, Shishmaref, Stebbins, Teller, Unalakleet, and Wales.

Some 1,400,000 gallons of fuel to these villages is transferred to lighters at Nome. About 3,019,600 gallons are delivered by ocean barges, accompanied by lighters, some of it possibly transferred directly from barges to lighters at Nome thus avoiding a delay at the tank farm or delivered from a tank farm at Bethel. It is known that shipments from Bethel capture the market on the lower Yukon River with the delta communities being supplied from there, but service from Bethel does not generally reach north beyond the Yukon River. The shipments asserted to avoid any of the tank farms at either location are characterized as direct shipments in the balance of this report and in the following table represent 3,019,600 gallons.

**Table 61. Villages Delivered Via Nome In The Without-Project Condition**

| Village Name | Village Population | Village Employment | Annual Fuel Use[124] (gal) |
|---|---|---|---|
| Brevig Mission | 261 | 80 | 232,000 |
| Deering | 141 | 44 | 127,600 |
| Diomede | 172 | 45 | 130,500 |
| Elim | 284 | 91 | 263,900 |
| Gambell | 636 | 124 | 359,600 |
| Golovin | 163 | 55 | 159,500 |
| Koyuk | 280 | 52 | 150,800 |
| St. Michael | 351 | 89 | 258,100 |
| Savoonga | 615 | 166 | 481,400 |
| Shaktoolik | 231 | 68 | 197,200 |
| Shishmaref | 537 | 173 | 501,700 |
| Stebbins | 507 | 161 | 466,900 |
| Teller | 278 | 58 | 168,200 |
| Unalakleet | 798 | 258 | 748,200 |
| Wales | 154 | 60 | 174,000 |
| Total | 5,408 | 1,524 | 4,419,600 |
| Amount Via Nome | | | 1,400,000 |
| Village Direct | | | 3,019,600 |

**Without-Project Fuel Delivery, Village Direct.** The 3,019,600 gallons shipped to the Village Direct destinations, as described above, can be simplified in the ensuing benefit analysis and viewed as if it were one shipment, because it consists of a delivery to lineally distributed villages in a consecutive series all in the vicinity of Norton Sound. The 15 Village Direct destinations are actually strung along a coastline of about 500 miles or on nearby islands, with the center of the group near Nome, about 2,150 miles from Puget Sound. Regarding distance from Portsite, the midpoint of the Village Direct group is about 300 miles. In the without-project condition shipments originate in Pacific northwest or the Kenai Peninsula.

One ocean barge is adequate to accommodate the 3,019,600 gallons, and the cost of delivery from Puget Sound is based on a distance of 2,150 miles. This may be somewhat of an overstatement, because an ocean barge is capable of carrying an additional load which could be

124 Disaggregated to individual villages using % employment is of total.

delivered to unknown destinations on the way to or from the "Village Direct" group. There is no consideration of backhaul, because the tug and barge are free to pursue other opportunities. Using the $1,362 hourly costs established elsewhere in this report, the cost is **$292,830**. Pump off cost does not change in the with-project condition and so is ignored.

**Without-Project Fuel Delivery to the Yukon Delta Villages**. In the without-project condition, the Yukon River and delta communities of Alakanuk, Emmonak, Kotlik, Pilot Station, Marshall, Mountain Village, Pitka's Point, St. Marys, Holy Cross, and Russian Mission, representing a fuel need of 3,764,100 gallons, are serviced either by a Yukon Fuel Company river barge coming down river from Tanana or by a coastal lighter delivering from a fuel terminal used by Crowley and Yukon Fuel Company at Bethel. On some occasions in the past, delivery has been from a Crowley terminal at Nome or from Crowley owned or Northland owned or Yutana owned barges on a coastal route, vending fuel bought originally in Puget Sound or Kenai, but this is no longer the anticipated delivery scenario. The communities of Scammon Bay and Sheldon Point (renamed Nunam Iqua in 1999), are in the delta area but south of the north mouth of the river which is considered to be the main navigation channel in this report.

**Table 62. Yukon Delta And Lower River Villages, Delivered From Bethel In The Without-Project Condition**

| Village Name | Village Population | Village Employment | Annual Fuel Use[125] (gal) |
|---|---|---|---|
| Alakanuk | 633 | 139 | 403,000 |
| Emmonak | 784 | 217 | 629,300 |
| Kotlik | 517 | 149 | 432,100 |
| Pilot Station | 550 | 112 | 324,800 |
| Marshall | 318 | 110 | 319,000 |
| Mountain Village | 738 | 180 | 522,000 |
| Pitkas Point | 125 | 33 | 95,700 |
| St. Marys | 504 | 219 | 635,100 |
| Russian Mission | 296 | 83 | 240,700 |
| Holy Cross | 227 | 56 | 162,400 |
| Total | 4692 | 1298 | 3,764,100 |

From a cost of supply standpoint, the newly established 10,000,000 gallon terminal, owned jointly by Bethel Native Corporation and Crowley Marine, is at a near even balance with Nome as the least cost source for customers on the lower Yukon River; however, in the without-project condition, Bethel is the most likely future source due to other economic considerations. The pivotal reason is that Yukon Fuel Company has a agreement for tank farm use at Bethel, while it has no storage at Nome. Therefore, it is in the company interest to continue to operate out of Bethel, thus avoiding a possible markup which would normally be expected if buying from a supply source owned by a competitor, Crowley Marine. Both companies appear well situated to continue service from Bethel.

The analysis in this report proceeds under the knowledge that the delivery, out of Bethel, to Yukon River delta communities does in fact produce net income from fuel sales and will continue to do so in the future. Augmenting this is the view that sales from Bethel are consistent

[125] Total allocated based on employment percentage. Gasoline is about 25% of the total.

with protecting a market share and getting a return on sunk costs such as the tank farm, regardless of whether this is a theoretically perfect strategy or the NED ideal. Since there are rational marketing concerns driving this strategy at the level of the firm, this report adopts the proposition that delivery from Bethel to delta communities will remain profitable in the without-project and with-project condition. Nevertheless the proposed Portsite project introduces a theoretically lower cost delivery through Nome and NED procedures require identification of the most efficient operation.

Because of the change in the with-project condition, the delta communities and their 3,764,100 gallons of fuel will enter the benefit evaluation along with 1,863,200 gallons to be delivered further upriver to the Yukon River Swing Villages. The total out of Bethel to these localities in the without-project condition will be 5,627,300 gallons. Regardless of the source of the fuel, there will be a lightering requirement, but it is quite likely to be the same in the with-project and without-project condition. This is explained by the fact that the river lighters would most likely pump off of a barge anchored at the river mouth in either case.

For the ocean link, 5.6 million gallons could be shipped in one barge load; however, depths at the tank farm will apply a draft restriction requiring at least two separate barges. The cost of delivery of fuel to Bethel is based on shipping by barge from the Kenai Peninsula, using equipment already mobilized, and which will not need to be returned to its origin due to other opportunities. Voyage length is 1,300 miles from Kenai to Bethel. Total season miles would be Kenai to Bethel, in up to three turns, or 3,900. This may be an overstatement in the sense the barge could be fully loaded at Kenai and deliver other destinations on the way to Bethel thus reducing the cost allocated for the Bethel link. It could also be argued that the cost of a return leg to Kenai could be discounted if the barge, in fact, delivered other destinations on the way to Bethel because the incremental distance related to supplying Bethel would be counted from the intermediate destination, not from Kenai.

Using the $1,362 hourly costs established elsewhere in this report, at an average speed of 10 statute miles per hour, the accumulated travel time and estimated NED travel cost would be 390 hours and **$531,200** respectively.

**Without-Project Delivery to 7 Yukon Swing Villages**. Moving further upriver on the Yukon, there are 7 villages with a combined population of 1,769, adding a demand for 1,863,200 gallons (6,340 tons) to the total.[126] The 7 Yukon Swing Villages and their estimated annual fuel use is summarized below:

[126] Estimated based on per job use in a sample year from data for 15 small coastal villages at 2,900 gallons per employee. Per employee use at Nome is 5,500, and at Kotzebue is 4,780, however use rates at regional economic, transportation, health and government centers are untypical of smaller coastal villages.

**Table 63. Yukon Swing Villages Estimated Fuel Use**

| Village | Population | Employment | Est. Gal. |
|---|---|---|---|
| Anvik | 104 | 29 | 84,000 |
| Shugeluk | 129 | 45 | 130,500 |
| Grayling | 194 | 52 | 150,800 |
| Kaltag | 230 | 69 | 200,100 |
| Nulato | 336 | 74 | 214,600 |
| Koyukuk | 101 | 40 | 116,600 |
| Galena | 675 | 334 | 968,000 |
| Total | 1,769 | 643 | 1,864,600 |

In the without-project condition they are also serviced either by a Yukon Fuel Company river barge coming down river from Tanana or by a coastal lighter delivering from a Crowley or Yukon Fuel Company fuel terminal at Bethel. In the with-project condition fuel service to these villages will come from Nome. The reason for identifying Nome as the source in the with-project condition is that, in the with-project condition, the fuel delivered to Nome for redistribution will be cheaper, and Nome will be more competitive at upriver locations where it does not now have a market share.

The lighter link without the project or with it, will be the same assuming the lighter would be filled from an ocean barge anchored at the river mouth (cost is included with the previous explanation of service to Yukon Delta Villages). The benefit evaluation for these Yukon River Swing Villages is based primarily on the $.15 per gallon savings in purchase cost at the origin.

**Without-Project Fuel Delivery to Kotzebue and Area Villages** Crowley Marine Services owns and operates a tank farm at Kotzebue with a capacity of 6,200,000 gal,[127] which is the main facility in the community and is operated as a regional reselling point including both wholesale and retail by Crowley Marine Services (Arctic Lighterage). In comparison, other local fuel storage capacity is minor consisting of 20,000 gallons of storage, owned by Bering Air and located at the local airport, 17,000 gallons of storage owned by the Air National Guard, and smaller amounts owned by Pacific Alaska Fuel Services, Baker's Fuel, Hanson's, Bison Street, Lee's Auto, K.I.C, and NAPA Auto Parts.

The immediate major fuel needs of the area are met through deliveries to Kotzebue, which takes about 7,750,000 gallons annually. In a typical year approximately 6 million gallons of product (includes HF #1, DF #2, aviation fuels, and unleaded gasoline) comes into Kotzebue and is consumed locally, which includes 1.5 million gallons for electrical generation. Practically all of the balance of the 7,750,000 gallons, about 1,750,000, is lightered to nine villages including Noorvik (368,300), Kiana (226,200), Ambler (162,400), Kobuk (37,700), Shugnak (153,790), Deering (162,400), Selawik (263,900), and Kivalina (139,200). A small part of the shipment to villages, about 180,000 gallons, is done by plane to villages when emergencies arise or when water transportation is unworkable. One other village, Noatak, has been receiving all of its deliveries by air since the river channel has become too shallow for barge traffic. Wood heating is popular at Noatak and fuel requirements are estimated at 50,000 gallons.

[127] http://www.crowley.com/cms/petroleum_transport.asp.

Forwarding of fuel from Kotzebue to villages on the upper reaches of the Kobuk River (Buckland, Noorvik, Kiana, Ambler, Kobuk, and Shugnak) depends annually on water levels, and on infrequent occasions when water levels are not sufficient, delivery to these villages is done by air.

All of the fuel delivered to Kotzebue in the without-project condition represents an "average year," and it all arrives by ocean going barge originating in Puget Sound or the Kenai Peninsula. The barges can hold in excess of 5 million gallons (up to 5.6 million), and they deliver over 1 million gallons (say 1.3 million gallons) at a time to Kotzebue, which allows the barges to have a shallow enough draft to call at the Portsite petroleum offloading dock where the balance of the load (say 4.3 million gallons) is delivered amounting to 6 trips to each location. The anticipated annual delivery to Kotzebue is:

**Table 64. Kotzebue Fuel Delivery**

| Use | Amount (gal) |
|---|---|
| End Use at Kotzebue | 4,500,000 (800,000 gas included) |
| Electric Generation at Kotzebue | 1,500,000 (no gas included) |
| End Use at Villages via Kotzebue | 1,750,000 (437,000 gas included) |
| Total | 7,750,000 |

For purposes of this analysis, the above fuel use has been incorporated as expected annual amounts with the assumption that annual variations will be small. Present day fuel use is unlikely to increase appreciably, considering low population growth rates and the high cost of fuel, which leads to increases in the number and type of conservation measures being implemented thereby stabilizing community fuel consumption.

In the without-project condition, the ocean link of the fuel delivery starts with one load from Puget Sound to arrive at Kotzebue then Portsite in late June or early July. For the rest of the season, deliveries are made by filling the barge near Kenai. Beyond the end of the last payload delivery cycle, tug and barge costs are irrelevant, because the equipment may pursue any available earning opportunity. Voyage lengths are 1,800 miles from Kenai to Kotzebue, 90 miles from Kotzebue to Portsite, and 2,450[128] from Puget Sound to Kotzebue. Total season miles would be:

| Puget Sound to Kotzebue, 2,450 one time | 2,450 |
|---|---|
| Kenai to Kotzebue, 1,800 five times | 9,000 |
| Kotzebue to Portsite, 90 miles six times | 540 |
| Empty backhaul Portsite to Kenai 5 times | 9,450 |
| Total Season Miles | 21,440 |

Total trips miles for a season would be 21,440. At an average speed of 10 statute miles per hour, the accumulated travel time and estimated NED travel cost would be 2,140 hours. Using the $1,362 hourly cost calculated, and a travel time of 2,140 hours, the travel cost is **$2,914,700.**

[128] In the with-project condition voyages from Puget Sound and Kenai are replaced with voyages of 6,200 miles from Singapore to Portsite and a mode shift to deep draft tanker.

In addition to the travel cost, the units will incur some time at anchor or at low power settings while being unloaded. This time taken to unload can vary widely due to weather conditions, and in extreme conditions, can require the tug and barge to seek shelter elsewhere and wait out the storm until conditions are favorable to the lighters and the offloading operation. It is possible, under the most favorable conditions in a protected harbor with no limitations on the receiving end, to offload 1,300,000 gallons in a few hours pumping at a maximum rate (peak pump off rates of 350,000 gallons/hour or 5,800 gal per minute), but on the open sea while offloading into a small lighter, anticipation of two days is more reasonable, and on rare occasion, the operation has been known to take several days. The equipment owner states that 2–4 days is their expectation for unloading one million gallons in a open water condition, and in this report, 48 hours is used with a downward adjustment of tug fuel use reduced by 50% with other costs unchanged = $1,044 for unloading = 6 loads x 48 hours x $1,044 = **$300,700**.

Pumping the remainder off at Portsite will be at the maximum rate calling for under 12 hours to empty each barge or a total of 72 hours costing **$75,200**. The without-project barge delivery cost is **$3,290,600**.

**Without-Project Fuel Delivery to Swing Villages**. The villages of Point Hope, Point Lay, Wainwright, Barrow, and Kaktovik are delivered by arrangements made by the North Slope Borough government headquarters in Barrow, which operates a subsidized fuel supply program for Borough villages, using a Crowley marine fuel barge that takes on fuel in Puget Sound and delivers to the villages. Point Hope has a "marine head" installed which allows the ocean barge to hook into a pipe and pump to a tank farm without using a lighter, but both Point Lay and Barrow are too shallow for the marine head facility to be installed so all of the fuel delivered there is lightered ashore.

According to information from the North Slope Borough, fuel delivered to the five villages is as follows:

**Table 65. Swing Village Fuel Needs**

| Village | Fuel Oil (gal) | Gas (gal) | Total (gal) |
|---|---|---|---|
| Point Hope | 999,000 | 87,000 | 1,086,000 |
| Point Lay | 442,000 | 15,000 | 457,000 |
| Wainwright | 969,000 | 110,000 | 1,079,000 |
| Kaktovik′ | 790,000 | 55,000 | 845,000 |
| Barrow | 1,300,000 | 1,660,000 | 2,960,000 |
| Total | 4,500,000 | 1,927,000 | 6,427,000 |

The delivery scenario and miles covered in the without-project condition is as follows:

| Puget Sound to Wainwright | 3,020 |
|---|---|
| Wainwright to Barrow | 100 |
| Barrow to Kaktovik | 315 |
| Refill Kenai | 2,465 |
| Kenai to Pt Hope | 1,800 |
| Pt Hope to Pt Lay | 140 |
| Total Season Miles | 7,840[129] |

Total trips miles for a season would be 7,840. At an average speed of 10 statute miles per hour, the accumulated travel time would be 784 hours. Using the $1,362 hourly cost calculated elsewhere, and a travel time of 784 hours, the transportation cost is **$1,067,800**. In addition to the travel cost the units will incur some time at anchor or at low power settings while being unloaded. This time taken to unload can vary widely due to weather conditions and in extreme conditions can require the tug and barge to seek shelter elsewhere and wait out the storm until conditions are favorable to the lighters and the offloading operation. It is possible under the most favorable conditions to offload one million gallons in several hours if the optimum pump capacity, line size, system pressure, and head conditions are met but this deteriorates to closer to two days at village terminals where conditions are not optimal and lines are generally 3 in. and with normal complications the operation has been known to take several days. The equipment owner states that 2–4 days is their expectation for unloading one million gallons even though the pump capacity is capable of doing the transfer in a few hours. Unloading into lighters has similar ranges of unloading rates, depending on how fast the lighter operator is willing to accept the load, how much line pressure he will accept, and how large the pipe is. In this report 48 hours is used as the transfer time per unit with a downward adjustment of tug fuel use by 50% with other costs unchanged = 5 stops x 48 hours x $1,044 = **$250,600**. The without-project ocean barge delivery cost to four Swing Villages is **$1,318,400**.

**Without-Project Summary of Fuel Delivery**. In the without-project condition, fuel delivery is made through Kotzebue and Nome, and directly to numerous coastal villages. Fuel is also delivered to Portsite to run the Red Dog Mine, and delivery to all of the destinations is required to be made using barges or lighters from barges anchored offshore. The process involves a certain amount of double handling, such as in fuel deliveries ultimately bound for Kotzebue or Nome area villages and which must first be brought into Kotzebue or Nome and redelivered from there. These deliveries are summarized as follows:

[129] The backhaul is not included because the barge is not empty after calling at Point Lay.

**Table 66. Summary Of Without-Project Condition Fuel Delivery (Including Double Handling**)**

| Destination | Mode | Tons | Gallons |
|---|---|---|---|
| Kotzebue | Ocean Barge and Lighter from Pacific Northwest (PNW) or Kenai | 26,350 | 7,750,000** (1,750,000 is redelivered) |
| Via Kotzebue to Villages | Lighter from Kotzebue | 5,950 | 1,750,000** |
| 5 Kotzebue Swing Villages | Barge from PNW and lighter transfer to shore | 21,850 | 6,427,000 |
| Nome | Ocean Barge from PNW | 34,000 | 10,000,000** (1,400,000 is redelivered) |
| Via Nome to area Villages | Lighter from Nome | 4,760 | 1,400,000** |
| Village Direct | Ocean Barge from PNW | 10,270 | 3,019,600 |
| 7 Yukon Swing Villages | Lighter from Tanana/Bethel | 6,330 | 1,864,600 |
| Yukon Delta/Lower River | Lighter from Bethel | 12,800 | 3,764,100 |
| Red Dog Mine @ 1,544,000 swt, post 2011 | Ocean Barge routed through Kotzebue | 87,420 | 25,712,900 |
| Total Of All Links And Nodes | | 209,730 | 61,688,200 |

# 13.0 FUEL DELIVERY WITH-PROJECT ROUTE AND COST

**Origin-Destination Shift.** The project will bring about a shift in the delivery routings and will expand the area serviced from Portsite. In the without-project condition fuel arrives at Portsite by barge. In the with-project condition fuel is delivered to Portsite site by deep draft tanker and redistributed from there. Large lots reshipped from Portsite to redistribution centers at Nome and Kotzebue are shipped by ocean going barge, while smaller lots, destined to other final destinations, are delivered by coastal lighters also directly from Portsite. Large barges are also used directly from Portsite to deliver in series to the Kotzebue Swing Villages and to Village Direct destinations as a least cost solution when compared to multiple trips by small lighter. For example, shipping large loads from Portsite to Nome is by ocean barge, while deliveries of small loads from Nome to villages near Nome are by small lighters. Air delivery is considered to be an emergency solution to events which will be the same with the project and without it.

**Mode and Route.** One aspect of all delivery routes is that a lower cost fuel source at Singapore will be accessed by deep draft tanker, and this will allow the barges operating out of Portsite to travel a larger delivery radius without increasing total delivered cost above that prevailing at any destination in the without-project condition. Because of the change in routes and the expanded area, the amount of fuel delivered through Portsite, in the with-project condition, adds the amount of fuel delivered through Nome and Kotzebue, the main distribution centers in the without-project condition. It also adds the fuel which is delivered directly to other locations in the Portsite favored radius. The table below identifies the mode or route which applies to the various destinations in the with-project condition, each mode or route being a least cost choice.

**Table 67. Gallons Of With-Project Condition Fuel Delivery (Including Double Handling**)**

| Village | Mode | Fuel | Gas | Total | Tons |
|---|---|---|---|---|---|
| Kotzebue | Ocean Barge from Portsite | 5,200,000 | 800,000 | 6,000,000 | 20,400 |
| Kotzebue area Villages | Lighter from Portsite | 1,313,000 | 437,000 | 1,750,000 | 5,950 |
| 5 Swing Villages | Coastal Barge from Portsite | 4,500,000 | 1,927,000 | 6,427,000 | 21,850 |
| Nome | Ocean Barge from Portsite | 8,000,000 | 2,000,000 | 10,000,000 | 34,000 |
| Nome area Villages | From Portsite to Nome then via Lighter from Nome | 1,100,000 | 300,000 | 1,400,000 | 4,760** |
| Village Direct | Ocean Barge and Lighter from Portsite | 2,777,600 | 242,000 | 3,019,600 | 10,270 |
| 7 Yukon Swing Villages | From Portsite to Nome then via Lighter from Nome | 1,398,500 | 466,100 | 1,864,600 | 6,330 |
| Yukon Delta/Lower River | From Portsite to Nome then via Lighter from Nome | 2,829,100 | 935,000 | 3,764,100 | 12,800 |
| Red Dog Mine | Deep Draft Vessel from Singapore to Portsite | 25,921,400 | 0 | 25,921,400 | 88,130 |
| TOTAL | | 53,039,600 | 7,107,100 | 60,146,700 | 204,500 |
| To Portsite | | 51,939,600 | 6,807,100 | 58,746,700 | 199,740 |

The shaded gallons total 58,746,700 and represent deliveries to Portsite in the with-project condition. Use at Red Dog Mine is based on the most likely production level of 1,544,000 swt and includes increased fuel demand from up rated generators to power the new ship loader and tugs to tend it.

Portsite will have two 4,000 HP tugs in service. Newly designed tugs of this size carry 92,000 gallons[130] of fuel which is adequate to power them to and from Portsite. They will top off once during the season and represent a potential 101,400 gallon demand for Portsite fuel, based on 690 assist hours during the season. The trestle-channel project includes generation efficiency which reduces fuel demand per kWh but adds mechanical equipment that increases electricity requirements. Overall the net result is to add a fuel requirement of 208,900 gallons over the without-project condition.

**With-Project Changes in Fuel Delivery Through Nome, Including Yukon Delta and Lower Yukon Villages.** For this economic study, 10,000,000 gallons has been selected as a mid-range estimate, typical of the expected annual delivery into Nome under present conditions. Under the with-project condition, the origin of fuel delivery to Nome will change from Puget Sound or Kenai Peninsula to Singapore via Portsite.

The 10,000,000 gallons delivered into Nome will be either used or re-shipped with the same pattern as the without-project condition. Therefore, the only savings for the ocean link is in the difference between bringing it to Nome from Puget Sound or Kenai Peninsula in the without-project condition and from Singapore to Portsite in the with-project condition.

There are 15 villages in the Nome area that are served either by a direct ocean barge delivery or lighter from Nome. The number of gallons delivered from re-shipping out of Nome is 1,400,000, (included in the 10,000,000 delivered there) and the number of gallons delivered direct by barge in the Nome area, without going through Nome, is 3,019,600. The 1,400,000 is included in the calculation of savings for delivery of the 10,000,000 gallons into Nome, while the 3,019,600 is treated elsewhere as a separate shipment with a cost difference.

With the project, lower cost will expand the area serviced out of Nome to include seven Yukon River Swing Villages, and they add a combined population of 1,769 and a demand for 1,863,200 gallons to the total.[131] In the without-project condition, they are serviced either by a Yukon Fuel Company river barge coming down river from Tanana or by a coastal lighter, delivering from a fuel terminal at Bethel. On some occasions in the past, delivery has been from a Crowley terminal at Nome or from Crowley owned or Northland owned or Yutana owned barges on a coastal route, vending fuel bought originally in Puget Sound or Kenai. On occasions, fuel barges, down bound from Tanana, have been filled at the upstream terminal from supplies brought through Fairbanks. Generally these supplies are exhausted early in the down bound trip.

From a cost of supply standpoint, the newly established Yukon Fuel Company, with access to a 10,000,000 gallon terminal at Bethel, is tied with Nome as the least cost source for customers on the lower Yukon River; however, Bethel is the most likely source in the without-project condition due to tank storage there useable also by Crowley Marine.

In the with-project condition, the total fuel shipped out of Portsite and either used at Nome or reshipped from Nome will include 10,000,000 gallons representing present conditions plus 1,863,200 gallons at Yukon Swing Villages, plus 3,764,100 gallons for the Yukon Delta and

[130] Verified with access to http://www.fwav.com/new_construction_details.htm. Design criteria for newly built tractor tugs.

[131] Estimated based on per job use in a sample year from data for 15 small coastal villages at 2,900 gallons per employee. Per employee use at Nome is 5,500, and at Kotzebue is 4,780, however use rates at regional economic, transportation, health and government centers are untypical of smaller coastal villages.

Lower River Villages = 15,627,300 gallons. In the without-project condition, the 5,627,300 gallons for the Yukon Delta and Yukon Swing Villages comes from Bethel and in the with-project condition it comes from Nome.

The reason for identifying Nome as the source in the with-project condition is that with Portsite, fuel going through Nome will be cheaper. Nome is within the capture area of Portsite, because the lower purchase cost of fuel in Singapore coupled with the use of deep draft tankers to get it to Portsite allows it to be delivered a greater distance without eroding profits or driving up the price beyond the without-project condition. The delivery radius has been estimated using $.15 gallon purchase saving, plus $.06 gallon saving for the ocean delivery. The saving is from a comparison of the cost of all gallons delivered including ocean and lighter links with a project and without a project as shown in the summary cost comparison table at the end of this section.

In an ocean barge of 5,250,000 gallons (depth limits at Portsite barge facility rule out fully loaded 5,250,000 ton barges) for the link between Portsite and Nome, the $.21 cushion amounts to $735,000. In this analysis the cost of a 5,250,000 gallon barge and a 3,500,000 gallon barge are only nominally different and for practical reasons are treated as being equal. At a cost and speed for the tug and barge of $1,362 per hour and 10 statute mph, this will yield an increased one way capture radius of 5,400 statute miles. Nome is about 315 miles from Portsite by water, and the travel distance eats up 6% of the $.21 per gallon saving, leaving a net saving of $.20 for each gallon delivered to Nome.

The estimated radius of 5,400 is reduced by half to 2,700 to account for the cost of a return leg. It is reduced again by taking into account the fact that the large ocean style barge will not be suitable for delivery into shallow coastal ports thus necessitating the assistance of a lighter and increasing the cost per gallon at some of the final destinations. The higher cost cuts the capture radius.

Since the lighters carry about 200,000 gallons or less, for shallow draft trips, they can add a considerable cost to the final leg, and for a trial calculation using a lighter trip of 60 miles, they erase savings at a rate of almost $.02 per gallon. If the entire load were to be subject to lighter delivery of 60 miles, the overall effect on lay down cost would reduce the radius by 540 miles to 2,160. However, this radius is meaningful only when there is not a competing radius which overlaps it, and this is not the case, because another competing radius would start at Anchorage, and one at Dutch Harbor or Adak. One radius will meet another at an equal cost frontier long before the economic limit of Portsite radius is reached, and the frontier presents the real economic barrier to extension of the service area—competition. In finite terms the limit of the competitive service area is not discernable except to state that it is significantly less than the estimated simplified radius wherein savings can be realized and at most no more than half the distance between Adak and Portsite, or Dutch Harbor and Portsite, or Anchorage and Portsite, which would indicate a Portsite favorable radius to the south and west, of well over 500 miles easily including Nome. To the north, the Portsite favorable radius includes all destinations without competition.

There is an excellent prospect for serving Nome directly from Portsite by use of an ocean going tug/barge combination drafting 17 ft, with a 12,000 dwst capacity, hauling 3,500,000 gallons per trip. Delivery to Nome, by ocean barge from Portsite, will be much cheaper than delivery to Nome, by ocean barge from the Puget Sound and Kenai areas. The lower delivered cost in the with-project condition will enhance deliveries to Nome and thence from Nome to the Yukon Delta and lower Yukon River communities.

There is no additional saving in serving the Yukon Delta and lower Yukon River communities with the exception of them receiving the advantage of lower purchase cost in Singapore, lower ocean transportation cost to Portsite, and lower bulk delivery cost to Nome. The redistribution cost using lighters from the tank farm to end users is equivalent in the without-project condition and with-project condition.

The annual fuel shipment to Nome will be the 10,000,000 gallons normally used at Nome or redistributed from there plus an additional 5,627,300 gallons added because of the expanded service area. Typically fuel into Nome is delivered aboard ocean going barges with equipment similar to that which serves Kotzebue. The Nome causeway is deep enough to accommodate the large barges; however, the existing barge dock at Portsite will not accommodate a fully loaded 5 million gallon barge. Therefore, a smaller barge will be used and the shipping of 15,627,300 gallons will require five deliveries. Cost of the tug/barge combination is estimated at $1,362 per hour. In the with-project condition, all five trips are from Portsite, a trip distance of about 250 miles. The five trips account for 1,250 load miles and 125 travel hours at $1,362 = $170,200, and **$340,500** with consideration of backhaul. Pump-off costs are unchanged.

With the use of deep draft tankers, cheaper fuel delivered at Portsite expands the area that can be served by lighters directly from Portsite by a 300 mile radius (200,000 gallon lighter load x $.15 reduced purchase price+.$06 transportation savings)/($557 lighter cost per hr x 8 statute mph)/(2 for round trip adjustment) = 300 statute miles. With this increased service radius, two additional villages now served from Nome (Wales and Shishmaref, referred to as two of the Swing Villages) could be served at less overall cost with lighters from Portsite thus adding 1,106,600 gallons per year (Wales 235,600 gallons and Shishmaref 871,000 gallons).

This theoretical expanded lighter service area has no significant consequence to the economics of Portsite, because the entire Nome distribution network falls within the ocean barge expanded service area of Portsite and in that sense is served either directly or indirectly from Portsite in practically any scenario that could be developed. This is because large ocean style barges out of Portsite can supply the tank farm at Nome and expand the capture area through Nome significantly beyond what can be provided by direct lighter service out of Portsite.

**With-Project Delivery to Village Direct**. The 3,019,600 gallons shipped to the Village Direct destinations are viewed as if it were one shipment, because it consists of a delivery to linearly distributed villages in a consecutive series, all in the vicinity of Norton Sound. The 15 Village Direct destinations are actually strung along a coastline of 500 miles or on nearby islands, with the center of the group near Nome, about 2,150 miles from Puget Sound. Regarding distance from Portsite, the midpoint of the Village Direct group is 300 miles. In the without-project condition, shipments originate in Pacific Northwest or the Kenai Peninsula.

One ocean barge is adequate to accommodate the 3,019,600 gallons so the benefit estimate is based on a comparison of barge delivery to the center of the group from the Puget Sound, with delivery from Portsite. This is a difference of 300 miles vs. 2,150 miles without consideration of backhaul. Using costs established elsewhere in this report, the cost difference is $292,800 minus $40,900, a savings of $251,900. In addition to the travel cost saving, the fuel purchase price differential of $.15 applies to the 3,019,600 gallons supplied through Portsite which represents an additional economic gain (reduced fuel cost) of $452,900 for a total saving of $704,800.

**With-Project Delivery to the Yukon Swing Villages.** A variety of smaller river lighters are used on the Yukon with draft limited capacity of around 200,000 gallons or less. Not every destination shares the same draft limitation, and a trip may start with 200,000 gallons or more, drawing less draft after every stop. Finally, carrying a load of 100,000 gallons or less, it can make practically every draft requirement.

The $.20 saving for each gallon delivered to Nome expands the delivery by lighter up the Yukon by up to 200,000 x $.20/$410 hour x 8 mph speed– 2 mph river current = 590 additional miles greater than the without-project condition, overlapping the midpoint of the river reach below Nenana. Thus, Portsite will make it possible to provide a lower cost fuel source for barges up bound on the Yukon River.

In the without-project condition, the Yukon villages are served by river barge heading downstream from Nenana which is situated above the confluence of the Yukon with the Tanana River. Close to Tanana, the barge will deliver serially to river villages, shuttling to Tanana for additional loads. Eventually the distance gets so great as to favor refilling at the mouth of the Yukon, Nome, or Bethel. When the barge reaches the mouth of the Yukon, it is available to take on fuel for the upstream trip, but in the with-project condition, the fuel will be priced lower at the river mouth because of the source available at Nome about 125 miles away. Therefore, in the with-project condition, the villages on the Yukon above the delta reach (Anvik, Shageluk, Grayling, Kaltag, Nulato, Koyukuk, Galena) will become more economical to serve from Nome, and they will add about 1,864,600 gallons to the amount of fuel delivered through Nome.

The number of trips with the project and without it is the same. In the past fuel has been taken upstream by Northland and others. Northland Holdings recently bought Yutana Barge Lines, and it is now known as the Yukon Fuel Company. The reason fuel is generally not taken upriver from Nome, in the without-project condition, is that Yukon Fuel has an upriver distribution system at Tanana and access to one at Bethel near the mouth of the Kuskokwim River, a major basin immediately to the south of the Yukon. The Tanana facility allows barges to load before going upriver and also allows them to deliver on the way down. The 10,000,000 gallon tank farm at Bethel allows barges to be loaded at a terminal which is further from the mouth of the Yukon then is Nome but avoids having to purchase fuel from a competitor at Nome and avoids the possible mark up.

In the with-project condition, fuel will be cheaper at Nome than Bethel, which gets its fuel supply by barge from Puget Sound and Kenai. If a lower fuel price is available through Nome, it is anticipated that a Nome based operator would arrange to supply fuel for upward bound barges. The shipping cost, with the project and without it, will be essentially unchanged, because the same equipment is making the same number of trips. It is just that, in the without-project condition, the barges are filled with fuel at Bethel for up bound deliveries, while in the with-project condition, they will be filled from Nome. Thus it is not transportation cost but the combination of production and lay down cost that is reduced.

A check of retail prices at Bethel and Nome in 2002 indicated prices at Bethel are slightly lower which is explained by Bethel being closer to the Puget Sound and Kenai sources. When the difference in distance is accounted for and Bethel and Nome are compared, based on reconstructed costs, delivery to the mouth of the Yukon is a toss up. Either way lighters begin their return trips with full tanks for delivery to villages along the lower river as they head upstream.

In the without-project condition, the practical economic limit of fuel delivery heading upriver is in the vicinity of Russian Mission. This places the seven Yukon Swing Villages, delivered from Nome, in the with-project condition only, within the Yukon reach where they can receive a saving of up to $.20 per gallon (combined saving of purchase price and deep draft tanker delivery) declining as the delivery proceeds upriver. Beyond Russian Mission starts the additional 590 approximate river miles of the Swing Village reach, and with each 100 miles traveled, the saving is reduced by about $.02–$.04 per gallon, depending on the load carried, which in turn depends on channel condition. The reach increment includes the seven Yukon Swing Villages, and for them, the average transportation saving is reduced to $.09 per gallon, recognizing that the saving will deteriorate with distance traveled, and this savings amounts to **$167,800** annually.

**With-Project Changes in Ocean Barge Through Kotzebue.** Kotzebue has an airport capable of year around jet service and has developed as a transportation center upon which villages in the region depend. Many of the villages, scattered through the interior and coast, are not able to accommodate ocean going barges that deliver supplies from Puget Sound ports; therefore, goods are transferred to lighters at Kotzebue where machinery, a work area, and warehousing exist. There are nine villages that receive shipments through Kotzebue by water or air in the without-project condition or which could otherwise gain transportation efficiency from improvements at Portsite. Of these, three (Deering Selawik, and Kivalina) are regularly accessible by water through the terminal facility at Kotzebue; six (Ambler, Kobuk, Shugnak. Kiana. Noorvik, Buckland) are accessible, subject to river conditions.

In the without-project condition, the ocean link of the fuel delivery to Kotzebue starts with one partial barge load from Puget Sound to arrive at Kotzebue with the balance of the load delivered to Portsite in late June or early July. For the rest of the season, the pattern is maintained except that deliveries are made by filling the barge near Kenai.

In the with-project condition, service to Kotzebue is directly out of Portsite, using two barges of 3,500,000 gallon capacity but loaded with 3,000,000 gallons to meet local needs. In the with-project condition, the surrounding villages are lightered from Portsite, and the cost of the lighter links is treated separately later in this section of the Appendix under the paragraph title Lighter Cost of Fuel to Villages. The distance to Portsite is 90 miles so the cost of two barge loads for a total capacity of 6,000,000 gallons is $49,000 for the ocean barge trips. To this is added the cost of unloading at 48 hours per and $1,044 per hour = $100,200, so the with-project cost is **$149,200.**

**With-Project Changes in Ocean Barge Service to Swing Villages.** Of the five initial Swing Villages (Point Hope, Point Lay, Wainwright, Barrow and Kaktovik), all five are supplied by ocean barge from Puget Sound through arrangements made by North Slope Borough, which include repositioning of the barge.

The Swing Villages will become economical to service by water from Portsite in the with-project condition. This is because the lower purchase price and the lower cost of a deep draft vessel delivery plus the advantageous location of Portsite are all economic advantages brought about by the project.

In the with-project condition, the villages are delivered by the smaller 3.5 million gallon ocean barge equipment; however, it will be staged from Portsite, the equipment already having been mobilized to the area. The miles (7,840) will be reduced to two round trips from Portsite to the direct villages (1,700 vessel miles) for a with-project cost of **$231,500**. The difference of 6,140 miles represents a travel cost savings of $836,300. Pump-off time and cost is unchanged for Point Lay, Point Hope, Wainwright, Barrow, and Kaktovik.

Two other villages (Wales and Shishmaref) are included with "Swing Villages" in the with-project condition. Savings, which will accrue to Wales and Shishmaref, are detailed in the report section which deals with differences in lighter cost, because they are delivered by lighters in both the with-project and without-project condition. The adjustment in lighter cost, by itself, is not a convincing case for saving to either; however, when one combines the reduced fuel purchase cost, both villages win out.

**With-Project Changes in Red Dog/Portsite Fuel Delivery**. In the without-project condition, barges are used to ship loads, averaging 4,000,000 gallons each, into Portsite barge dock. In this analysis the cost of shipping the barge loads is included in the cost of supplying Kotzebue because they call there first. The Kotzebue scenario accounts for all barge and tug costs from the origin at Seattle until the return of an empty unit at the end of the cycle.

In the with-project condition, all fuel for 47 destinations and the mine comes from Singapore. The total gallons to be shipped into Portsite will be 53,118,000. This includes Kotzebue and the previously discussed seven Kotzebue satellite villages and six Swing Villages. Also, Nome and the satellites delivered from it; plus the Yukon River villages and villages delivered direct by ocean barge will all be delivered through Portsite. Fuel is to be transferred at Portsite to ocean barges or lighters depending on the least cost manner of delivery on the final leg.

The cost of deep draft tanker service to Portsite from Singapore is based on standard Corps of Engineer sources for deep draft vessel costs, reduced to a cost per ton and per day. The selected vessel is a foreign flag tanker with a dwst capacity of 55,000 tons, loaded with 49,935 tons of fuel. It has an hourly cost at sea of $806 and $633 hourly in port. Each year four vessel trips are required for the 6,200 mile trip. At a speed of 22 mph, the vessels require a total of 47 days travel time. At a daily cost of $19,344, vessel travel cost is $909,200. Allowing eight vessel days (two days per) for fuel transfer at Portsite, and a daily in port cost of $15,192 adds $121,500 for a total delivery cost of **$1,030,700**, about $.02 per gallon.

**With-Project Lighter Cost of Fuel to Villages**. Hourly operating cost of typical lighters has been established earlier in this report. For a supportable estimate of the delivery cost of fuel, the lighter operations need to be linked to destinations in terms of distance, quantity, and delivery cost. In the without-project condition, fuel is delivered using Kotzebue and Nome as primary redistribution points for a fleet of lighters with Portsite and coastal "Swing Villages" being served directly. In the with-project condition, Portsite becomes the major hub for all fuel shipments with Kotzebue, Nome, the "Swing Villages," and numerous others being supplied from there as listed in the following tables. The villages, in the tables, are singled out because they are related to changes between the with-project and without-project condition.

**Table 68. Destination Villages Using Kotzebue Transfer Without-Project And Changing To Portsite Transfer With-Project**

| Name | Access |
|---|---|
| Ambler | River |
| Kobuk | River |
| Shugnak | River |
| Kiana | River |
| Noorvik | River |
| Buckland | River |
| Deering | Coastal |
| Kotzebue | Coastal Terminal |
| Selawik | Inlet |
| Kivalina | Coastal |
| Noatak | Air only and no change with-project |

**Table 69. Destination Villages Or Intermediate Connections From Portsite With-Project**

| Name | Access |
|---|---|
| Kobuk | River (Kotzebue transfer w/o) |
| Ambler | River (Kotzebue transfer w/o) |
| Shugnak | River (Kotzebue transfer w/o) |
| Kiana | River (Kotzebue transfer w/o) |
| Noorvik | River (Kotzebue transfer w/o) |
| Buckland | River (Kotzebue transfer w/o) |
| Deering | Coastal River (Kotzebue transfer w/o) |
| Kotzebue | Coastal Terminal (Puget Sound w/o) |
| Selawik | Inlet River (Kotzebue transfer w/o) |
| Kivalina | Coastal River (Kotzebue transfer w/o) |
| Noatak | Air only and no change with-project |
| Point Hope | Coastal (Puget Sound origin w/o) |
| Point Lay | Coastal (Puget Sound origin w/o) |
| Barrow | Coastal (Puget Sound origin w/o) |
| Wainwright | Coastal (Puget Sound origin w/o) |
| Kaktovik | Coastal (Puget Sound origin w/o) |
| Nome | Coastal Terminal and Gateway to 32 satellite villages by water (Puget Sound and Tanana origin w/o) |

Origin-destination distances are available by using up to date maps; unfortunately, there is no readily available, uniform, reliable measure of fuel used at many of the villages, such as the group of Ambler, Kobuk, Shugnak, Kiana, Noorvik, Buckland, Deering, Selawik, and Kivalina. There is, however, a reliable measure of total fuel delivered by water to all nine, and it amounts to 1,750,000 gallons in a typical year. This is from tank farm throughput data at Kotzebue.

In order to estimate the fuel delivery cost individually to each village, it is necessary to allocate the amount of fuel anticipated to be used at each destination. Consideration was given to extending fuel use per capita at Kotzebue with an adjustment for intensity of development differences among the villages. However, an overestimate would result if total regional fuel use were to be reduced to a per capita amount and applied to village population to estimate village consumption, because Kotzebue is a regional center with commercial activity, large government, educational, and social facilities not found in some of the villages. Kotzebue has one third of the regional population, two thirds of the jobs, and uses eight tenths of the fuel.

In the estimate of village specific fuel use, the local development influence on fuel use is accommodated by dividing the fuel use by the number of jobs in the villages and then using the number of jobs at each location to estimate the local fuel use for each village. The reason for doing this is that villages with low employment have lower incomes, a greater propensity for subsistence life style, and consequently a lower fuel use. This is supported by a comparison of bulk fuel storage facilities which indicated the wealthier communities had larger storage facilities. So, the estimate of fuel delivered by water to a given village is: jobs in one village/jobs in all villages x 1,750,000 gallons. For purposes of this benefit evaluation, only the fuel delivered by water is quantified because it is the mode that is anticipated to experience changes in the with-project condition. The water delivered portion of annual fuel use is an average of 2,150 gallons per job.

All of the villages in the Kotzebue area are also markets for fuel delivery by air. Air delivery is used, because many of the villages are not reliably accessible by water, due to shoaling of access channels and seasonal fluctuations in water levels. Another reason for air delivery is that air service is used to re-supply villages when fuel supplies run out before barge delivery can take place following the ice break-up. Both of these circumstances are anticipated to be unchanged in the with-project condition.

Fuel supply by air is estimated to account for an additional 607,000 gallons, when total use for the nine villages is estimated, using an average of 2,900[132] gallons per employee and a total of 813 jobs. Total use at the nine villages is, therefore, 1,750,000 gallons, delivered by water plus 607,700 delivered by air = 2,375,700 gallons.

Cost of delivery was estimated by routing short trips and small deliveries in up to 200,000 gallon loads to the villages at eight mph and by providing multi-village service where villages can be visited serially. It is recognized that lighter operations can be operated with multiple barge units thus increasing the number of gallons carried and reducing the cost per gallon accordingly. One such operation is known to consist of two self-powered lighter units, which have been permanently joined. In this report units with starting loads of 200,000 gallons have been used to avoid inflation of the savings estimate. As some villages are delivered, the load gets lighter, allowing most of the draft limited destinations to be delivered without requiring an equipment change.

Longer coastal trips and larger loads are delivered in large ocean style barges at significantly higher hourly cost but with an overall reduction in cost per gallon. This combination of services provides an estimate of the cost of serving the villages without the project and with the project. The result is a net increase in lightering cost of some $106,400 annually. The estimate accounts for a possible shift in villages which would be served from Portsite due to lower overall cost when other components of the delivery cost are considered.

[132] Average total use based on data for 15 small coastal villages.

**Table 70. Lighter Link Cost Without-Project**

| Village | Mode | Distance Without | Gallons of water delivered fuel | Trip Data$557 or $410/hr @ 8 mph and 680 tons per (200K gal) | Cost W/O Project |
|---|---|---|---|---|---|
| Ambler | Kobuk River Barge | 130 to Kotzebue | 162.4 | See Noorvik | See Noorvik |
| Kobuk | Kobuk River Barge | 140 to Kotzebue | 37.7 | See Noorvik | See Noorvik |
| Shugnak | Kobuk River Barge | 150 to Kotzebue | 153.79 | See Noorvik | See Noorvik |
| Kiana | Kobuk River Barge | 60 to Kotzebue | 226.2 | See Noorvik | See Noorvik |
| Noorvik | Kobuk River Barge | 50 to Kotzebue | 368.3 | 5 RT = 1,020 mi= 127 hr | $52.3 as multi service |
| Buckland | "B" Barge | 75 to Kotzebue | 188.5 | | See Deering |
| Deering | "B" Barge | 60 to Kotzebue | 162.4 | 2 RT = 270 mi = 34 hr | $13.8 as multi service |
| Kotzebue | Coastal Barge | 0 to Kotzebue | 7.75 mil | 39 RT 4hr per = 156 hr | $86.9 |
| Selawik | River Barge | 70 to Kotzebue | 263.9 | 2 RT 280 mi = 35 hr | $14.3 |
| Kivalina | Coastal Barge | 90 to Kotzebue | 139.2 | 1 RT =180 = 23 hr | $12.8 |
| Noatak | Air | 50 | | | No change |
| Point Hope | Coastal Barge Connection | Nil | 999.0 | None (marine head) | Nil |
| Point Lay | Coastal Barge offshore transfer | 5 | 442.0 | 3 RT 30 mi =4 hr | $2.1 |
| Wainwright | Coastal Barge Connection | Nil | 969.0 | nil | Nil |
| Barrow | Coastal Barge | 5 | 1,300.0 | 7 RT = 70 mi | $4.9 |
| Kaktovik | Coastal Barge | 5 | 845.0 | 5 RT = 40 mi | $2.8 |
| Wales | Coastal Barge from Nome | 125 to Nome | 133.4 | 1 RT=50mi = 32 hr | $17.8 |
| Shishmaref | Coastal Barge from Nome | 220 to Nome | 371.9 | 2 RT =880 mi = 110hr | $61.3 |
| Total | | | 9.157 Mil | | 269. 0 |

**Table 71. Lighter Link Cost Net Difference With-Project Compared To Without-Project**

| Village | Mode | Miles With | Distance Without | Net | Gallons of water delivered Fuel | Trip Data $557 or $410/hr@ 8 mph and 680 tons per (200K gal) | Cost W/O Project less With Project |
|---|---|---|---|---|---|---|---|
| Ambler | Kobuk River Barge | 220 to port site | 130 to Kotzebue | +90 | 162.4 | See Noorvik | See Noorvik |
| Kobuk | Kobuk River Barge | 230 to port site | 140 to Kotzebue | +90 | 37.7 | See Noorvik | See Noorvik |
| Shugnak | Kobuk River Barge | 240 to port site | 150 to Kotzebue | +90 | 153.79 | See Noorvik | See Noorvik |
| Kiana | Kobuk River Barge | 150 to port site | 60 to Kotzebue | +90 | 226.2 | See Noorvik | See Noorvik |
| Noorvik | Kobuk River Barge | 140 to port site | 50 to Kotzebue | +90 | 368.3 | 5 RT = 900 added mi= 113 hr | Add $46.3 as multi service |
| Buckland | "B" Barge | 165 to port site | 75 to Kotzebue | +90 | 188.5 | | See Deering |
| Deering | "B" Barge | 150 to port site | 60 to Kotzebue | +90 | 162.4 | 2 RT = 360 added mi = 45 hr | Add $22.9 as multi service |
| Kotzebue | Same as w/o | Same as w/o | | | Same as w/o | Same as w/o | Same as w/o = 0 add |
| Selawik | River Barge | 160 to port site | 70 to Kotzebue | +90 | 263.9 | 2 RT 360 mi = 45 hr | Add $18.4 |
| Kivalina | | 15 to port site | 90 to Kotzebue | -75 | 139.2 | 1 RT = 150 mi saved = 19 hr | Save $10.4 |
| Noatak | Air | 50 | 50 | - | -------- | | No chang |
| Point Hope | Same as w/o | Same as w/o | Nil to Barge | 0 | 1,086.0 | No lighter | 0 |
| Point Lay | Same as w/o | Same as w/o | 5 to Barge | 0 | 457.0 | Same as w/o | 0 |
| Wainwright | Same as w/o | Same as w/o | nil | 0 | 1,079.0 | Same as w/o | 0 |
| Barrow | Same as w/o | Same as w/o | 5 to Barge | 0 | 2,960.0 | Same as w/o | 0 |
| Kaktovik | Same as w/o | Same as w/o | nil | Same as w/o | 845 | Same as w/o | 0 |
| Wales | Coastal Barge from Nome | 180 to port site | 125 to Nome | +55 | 133.4 | 1 RT = 110 mi -= 14 hr | Add $7.7 |
| Shishmaref | Coastal Barge from Nome | 110 to port site | 220 to Nome | -110 | 371.9 | 2 RT =440 mi = 55 hr | Save $30.6 |
| TOTAL | | | | | 9.157 mil | | Add $54,300 |

The foregoing tables illustrate the lighter delivery cost with and without Portsite as a distribution center.

Main delivery route changes are not reflected in the table, only the lighter link. For example, in the with-project condition, the five villages of Point Hope, Point Lay Wainwright, Barrow, and Kaktovik are delivered by the smaller 3.5 million gallon ocean barge equipment; however it will be staged from Portsite, the equipment already having been mobilized to the area. The without-project condition miles (7,840) will be reduced to two round trips from Portsite to the Swing Villages (1,700 vessel miles) for a with-project cost of $231,500. The difference of 6,140 miles, representing a travel cost savings of $836,300, has been counted earlier. Pump-off time and cost, and lighter use are unchanged from the without-project condition.

The largest available equipment has a high hourly cost, but even at a cost of $1,362 per hour, use of the 3,500,000 gallon barge and 10,000 HP tug will result in a lower overall delivered cost compared to smaller lighters for deliveries over about 500,000 gallons.

**With-Project and Without-Project Comparison.** The analysis of fuel delivery applies a number of variables influenced in their development by expert opinion, sampling, informal interviews, and anecdotal sources. These variables are applied consistently throughout the analysis, and the effect of varying them is tested in the sensitivity analysis part of this report. Among them are the estimated types of equipment selected as typical of the transportation system, vessel costs, travel rates, travel distances, and fuel use. Perhaps the most sensitive of the variables are vessel cost and travel rate; however, the analysis has selected defensible values and applied them in a manner which would not overestimate the beneficial effects of the proposed project. Overall beneficial effects related to fuel transportation are summarized in the table below:

**Table 72. Summary Of Effects of Fuel Transportation**

| Item | Cost W/O Project ($) | Cost With-Project ($) | Difference ($) |
|---|---|---|---|
| Delivery to Portsite and Kotzebue+Satellites | 3,290,600 | 1,030,700[133]<br>149,200[134] | 2,110,700 |
| Cost to Nome+Satellites | 1,024,600 | 340,500 | 684,100 |
| Village Direct | 298,800 | 40,900 | 257,900 |
| Swing Villages | 1,318,400 | 231,500 | 1,086,900 |
| Yukon Villages | 531,200 | 531,200 | nil |
| 7 Yukon Swing Villages | base | 167,800 delta | 167,800 |
| Lighters | 269,000 | 214,700 | 54,300 |
| Fuel Cost | Base value w/o | -8,812,000 delta[135] | 8,812,000 |
| Total | | | 13,173,700 |

**Fuel Storage Needs.** Total fuel delivered to Portsite in the with-project condition will be 58,746,700 gallons, which includes 6,807,100 gallons of gas. Parsing will be made in four trips, with adequate time between the first three trips to refill the 15 million gallon Portsite tanks. The tanks can be comfortably be emptied into barges holding 3,500,000–5,350,000 gallons inside of a 2–4 day period. The last delivery will be at the end of the season to fill the tanks for the winter.

Total fuel requirements include 6,807,100 gallons of gas, which will require storage of its own. With four deliveries, each shipment would require about 1,701,800 gallons of tank storage. It is proposed that 2 million gallons of gas storage will be adequate at Portsite. This will allow the tanks to be filled at the first delivery of the season, with an additional 3.4 million gallons of throughput during the season, leaving them empty at the end. The first 2 million gallons could go to Nome by ocean barge, the next 2 million to Nome for redistribution, then about 2 million to Kotzebue, then the village destinations.

The cost for the first four tanks constructed in 1988–1989 was $9,750,000 for 10 million gallons, or $.975 per gal. Tank six was budgeted for $2,750,000, but actual costs in 2001 were

[133] This represents the total deep draft tanker shipping cost of all fuel into Portsite.

[134] Lighter link to Kotzebue.

[135] Total fuel shipment 58,746,700 gallons @ $.15/gallon saving.

$1,350,000, which is believed to be understated when compared to a "stand-alone" project. Tank six was part of the much larger process improvement and expansion at the mine. For purposes of including the associated cost of 2 million gallons of added storage in the with-project condition, a new cost estimate was made.

At about half of one percent of the annual cost of the NED plan, the associated cost of fuel storage is too small to impact project selection, maximization, or justification. Therefore, it does not appear in the details of the many alternatives. It is, however, included in the cost of the NED plan, using cost estimating techniques consistent with procedures used to estimate overall project cost.

**Fuel Delivery System**. The with-project fuel delivery system requires reliance on centralizing deliveries through Portsite. The system, as it exists in the without-project condition, does not transship fuel through Portsite so some systematic modifications outside of the actual planned NED project will need to be effected if the benefit stream is to be realized. There is no guarantee that a delivery system will materialize; however, it is a rational idea with widespread financial benefits to be realized among some 47 villages.

There has been considerable discussion among the benefiting villages about organizing to take advantage of the centralized fuel terminal operation at Portsite in a way that will pass the savings onto villagers. One plan is organization of a non-profit cooperative to broker and manage fuel shipments.

Formation of a non-profit cooperative is not the only means of fuel delivery through Portsite. The companies presently involved in fuel delivery from Puget Sound and Kenai peninsula origins could easily provide service through Portsite without creation of a cooperative. In either case, the fuel could be shipped into Portsite at a lower cost, and NED savings would be generated. In the case of privately owned companies, there would be a potential for higher profits for those involved in the delivery. Among the beneficiaries, there are no known individuals or groups in opposition to the provision of cheaper fuel.

It is presumed that any party or organization interested in developing a fuel distribution system through Portsite will need time to develop a plan, marshal support, organize financing, put a legal framework in place, and so on. Most likely, this will all follow a real time observation of the workability of Portsite as a fuel depot for a season or two. Actual development of a system for regular and reliable delivery to village destinations could take several years, possibly as long as 3–5 years.

**Durability of the Cost Savings**. There are two major considerations to be accounted for in conversion of the annual savings in fuel cost to an equivalent annual NED benefit:

Project Economic Life. The various plans come online in 2011 and remain in service 50 years to 2061. The cost savings from village delivery will persist over the 50-year period. However, the mine life will expire in advance of the 50-year period (around 2042). Fuel delivery savings accruing to Red Dog Mine must, therefore, be adjusted in an annualizing calculation.

Fuel Distribution System. Fuel distribution benefits to villages hinge on development of a cooperative delivery vehicle, and time must be allowed to accomplish this. Benefits to Red Dog Mine, however, are far easier to capture as the delivery mechanism is simply participation by TCAK in the lowest cost option and does not depend on cooperation among a number of widely dispersed villages. The calculation of benefits allowed four years for effecting the village delivery protocol and treated delivery to Red Dog as an immediate activity.

**Fuel Benefits to the Mine**. About 44% of the total fuel shipped is destined for Red Dog. Total savings of all fuel shipped are $13,173,700, so savings to Red Dog are estimated at $5,796,400. They persist for 31 years of the 50-year project economic life so have a present worth and equivalent annual value at 5 3/8% of $86,562,800 and **$5,019,000,** respectively.

**Fuel Benefits to the Villages**. About 56% of the total fuel shipped is destined for villages. Total savings of all fuel shipped are $13,173,700, so savings to villages are estimated at $7,377,300. They do not start to be realized until the 4th year of the project life so have an equivalent annual value at 5 3/8% of **$5,983,400**.

**Total Equivalent Annual Benefit**. Total annualized savings related to changes in fuel delivery are **$11,002,400**.

# 14.0 BENEFIT COST FRAMEWORK

**Purpose**. The purpose of this section of the feasibility report is to present the economic analysis on which the plan selection, optimization, and economic justification are based. The analysis uses the Principles and Guidelines (P&G)[136] as interpreted by the Corps in ER 1105-2-100. The P&G are applied to assure proper and consistent planning by Federal agencies in the formulation and evaluation of water and related land resource implementation studies. The fundamental consistency, which the P&G strives, for is the National Economic Development (NED) objective: "...to contribute to national economic development consistent with protecting the nations environment pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements...Contributions to the NED are increases in the net value in the nation's output of goods and services, expressed in monetary units."

The Corps of Engineers issues Engineering Regulations, instructing that specific methods be used when evaluating projects, serving specified purposes. The methods are presented in the spirit of the P&G as "guidance" recognizing that planners must be allowed a certain latitude in adapting methods to the many and varied situations typical of water resource problems. This analysis maintains a consistency with the NED objective and implements the P&G in the spirit of identifying and quantifying the NED benefits.

In this section NED benefits are quantified for various scales of alternative plans in order to evaluate the relative attractiveness of the various development options. For the combination trestle and channel projects, this will include project depths of 53 ft, 50 ft, 47 ft, 45 ft, and 42 ft. Of these, the three deepest were evaluated at two commodity throughput levels, namely 1,544,000 swt and 1,729,000 swt with 1,544,000 swt reflecting the most likely output level during the evaluation period, and 1,729,000 swt reflecting a scenario incorporating a potential but unlikely increase near the year 2011 which would be maintained for the remainder of the evaluation period. The two different tonnage levels represent two points in a continuum and as such represent a means of stating range effects in specific and consistent terms. The two shallower depths are given less space in the discussion, because it became obvious that the NED scale would occur above 47 ft.

For each of the alternative plans, the equivalent annual benefit is calculated, based on a 5 3/8% discount rate, 50-year project life, a post-project mine production life limited to 31 years, and a project year-one of 2011. It may be possible for a nonstructural plan to come online earlier than 2011; however, the effect of an early online date on overall attractiveness of any alternative is not significant enough to have a material affect on the array of choices.

**Methodology**. The analysis is based on a comparative review of the origin to destination costs for concentrate, shipped from the Red Dog Mine, and petroleum fuel, shipped into it and to the area villages. These comparative costs include the effects of vessel delay due to weather exposure, harbor limitations and related congestion, as well as the queuing of barges and deep draft vessels, differences in loading rates, route shifts, and equipment variations. Costs also differ because of differences in load potential due to fleet variations resulting from different depths under consideration.

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[136] Economic and Environmental Principles for Water and Related Land Resources Implementation Studies 18 CFR Parts 711, 713, 714 and 715.

To simplify the illustration in support of the benefit evaluation, the analysis has been reduced to a set of comparative tables showing the cost of certain aspects of the shipping operation with the project and without it.

A cost comparison for general cargo is not shown because the manner of shipping it into the mine and the area villages is not anticipated to change with the project. For ease of following the analysis, the following recaps how the shipping will differ with the project and without it:

- **General Cargo**. Without the project, in the case of area villages, general cargo is anticipated to be shipped to the end users by ocean going barges which will anchor offshore; lighters will be used to move the cargo to a shore-based staging area where the cargo will then be transshipped to end users. This does not change in the with-project case, because the proposed improvements do nothing to improve efficiency of the delivery or cut the cost of general cargo. With Portsite improvements, it is impractical to divert community bound general cargo through Portsite, because Portsite is not planned to be equipped with additional general cargo handling facilities such as warehousing, secure storage, cranes etc. This should not be taken to mean that there is absolutely no potential for moving general cargo to some villages through Portsite. There is a small projected increase in general cargo bound for Portsite, because it is needed to support mine activities, given a possible but unlikely increase in production levels.

Direct offloading of containers or break-bulk cargo onto the new dock, using ship's gear, a land-based forklift for handling on the dock, and a tractor trailer unit to haul containers to the shore storage area is incidental to Portsite improvements. Although this is highly uncertain, there may be some small benefits to TCAK for direct importation of mine supplies, such as grinding balls based on containerized shipment in geared bulk carriers from Asia, rather than indirectly through the present staging area in Seattle. In theory this is possible without the project, because containers could be landed from bulk carriers onto dry cargo barges and lightered to shore. For this reason, the small number of tons involved, the savings per ton, and the potential adverse affects of the general cargo operation on the bulk loading aspects of the terminal are very difficult to support with confidence—general cargo was not quantified as a benefit category.

Because of the uncertain benefits, capital cost was not added to allow for general cargo handling. Ability to handle general cargo is a by-product of the proposed dock construction methodology, whereby the dock is constructed as a deck barge, towed to the site, and jacked up. It is also a by-product of a decision to provide truck/crane access to the dock to allow for heavy maintenance without the need for a barge and crane. The 90 x 300 ft barge dimension works geometrically for two fixed radial shiploaders and provides sufficient working area for construction equipment to erect the dock equipment, without use of another erection barge. The clear deck area remaining is sufficient for incidental handling of general cargo.

- **Concentrate Shipments**. In the without-project condition, a tug/barge system is used to shuttle barge loads out to deep draft vessels anchored offshore. This is necessary because the dock, where the barge loading is done, is much too shallow for the ocean going bulk carriers. In the with-project condition, the proposed combination channel-trestle project addresses this by allowing the deep draft carriers to be loaded directly from a conveyor system mounted on a trestle. The loading terminal is dredged deep enough to make a navigation channel a practical and economical component of the project. The proposed project streamlines the loading operation by replacing the intermittent, and high cost tug and barge trips with a continuous loader, saving some operating cost in the process. It also allows a higher throughput and lower lost time; both of which have some positive economic value.

The benefit evaluation deals separately with saving to the tug and barge operation, saving to the cost of deep draft vessels in port and in queue, saving to the actual ship transit cost, and value of induced tonnage.

- **Petroleum Shipments**. In the without-project condition, petroleum delivery to Portsite is by ocean going barges, which call first at Kotzebue and anchor offshore there to have some of the fuel lightered to storage ashore. This lessens the draft of the vessel so it can call at the Portsite facility with a safe underkeel clearance.

In the with-project case, petroleum shipments will arrive at Portsite by use of deep draft tankers sailing directly to Portsite from a foreign supply port. There will be no fuel delivered to Kotzebue or other area coastal villages except fuel that is to be transferred from Portsite. This eliminates the transfer of fuel from Kotzebue to the villages and modifies the ocean barge delivery of fuel to Kotzebue, Nome, and villages delivered direct. In the process a lower cost point of purchase is made possible, and economies of scale are offered by deep draft tanker vs. ocean barge.

The prospect of fuel delivery to Portsite, with a deep draft tanker, will allow Portsite to serve as a regional fuel distribution system. The resulting lower cost of fuel delivery will expand the delivery radius making Portsite the main node in deliveries of fuel to a sparsely populated land area, almost as large as the state of California.

The benefit calculation for petroleum tallies all of the transportation costs from origin to destination for the with-project and without-project condition. This tally shows shifts in the routings which precipitate a need for different equipment combinations. Equipment costs are a major input to the benefit calculation.

**Alternatives, Data Sources, and Assumptions**. In this benefit evaluation, data appears, which is developed in other sections of the report. Rather than reproduce the text in detail, the benefit evaluation uses a short discussion adequate to understand the general nature of the data but not intended to be adequate to support it. Information relating to the projected commodity levels, fleet mix, vessel operating cost for deep draft and tug/barge operation, voyages, induced tonnage, petroleum shipments, etc., are all developed elsewhere. One of these specialized sections deals with a description of the probabilistic simulator used to derive throughput capacity and vessel queuing for the alternative plans that survived the initial screening. The alternatives include:

Without-Project Condition. This is a no-action baseline. It serves as the basis for comparisons of accomplishments of other alternatives. It is also a real alternative in the sense that no-action is a possible outcome of the planning process.

Alternative 2–3 Barges. This plan adds a third self-unloading barge to the two existing self-unloaders. For plan effectiveness and flexibility a fifth tug is also required. This is referred to as "Alt 2-3rd Barge."

Alternative 3–Breakwater. A breakwater is introduced to shelter the tug and barge operation. This is referred to as "Alt 3-BW."

Alternative 4–3 Barges and a Breakwater. These are introduced together seeking maximum output from the existing tug and barge mode. This is referred to as "Alt 4-3$^{rd}$ B & BW."

Alternative 5–Channel and Trestle Without Fuel. The channel-trestle combination would not include a fuel delivery element. This is referred to as "Alt 5-CH+TRS (w/o F)."

Alternative 6–Channel and Tunnel Without Fuel. In this plan a tunnel replaces the trestle. It does not include a fuel element. This is referred to as "Alt 6-CH+TUN (w/o F)."

Alternative 7–Offshore Fuel. This plan leaves the tug and barge operation in place and provides an offshore terminal for fuel transfer and adds to the tank farm. This is referred to as "Alt 7-OF."

Alternative 8–Offshore Fuel and 3 Barges. Fuel is provided by an offshore terminal, and the concentrate loading operation is modified with the use of a third barge with an additional tug. This is referred to as "Alt 8-OF+3B."

Alternative 9–Offshore Fuel and Breakwater. Fuel is provided by an offshore terminal, and the concentrate loading operation is modified with the construction of a breakwater. This is referred to as "Alt 9-OF+BW."

Alternative 10–Offshore Fuel, Three Barges and a Breakwater. Fuel is provided by an offshore terminal, and the concentrate loading operation is modified with the addition of a third barge and construction of a breakwater. This is referred to as "Alt 10-OF+3B+BW."

Alternative 11–Channel and Trestle with Fuel. This includes various depth channels in combination with varying length trestles. All of these channel-trestle combinations include facilities for fuel transfer and storage. This is referred to as "Alt 11-CH+TR (w/F)."

Alternative 12–Channel and Tunnel with Fuel. This replaces the trestle with a tunnel and is referred to as "Alt 12-CH+TUN (w/F)."

Some of the key parameters in the analysis of all the alternatives are as follows:

- Regarding concentrate shipments, O-D pairs and vessel routing will remain the same for any tonnage level, because Red Dog provides concentrate at a marginal cost well below the industry average cost.

- The 4,000 HP ocean going line-haul tug, used in the without-project condition, will be comparable cost-wise to tugs of equivalent HP used at site in the with-project condition. The with-project condition employs two 4,000 HP tractor tugs. These are accommodated in the project cost estimate.

- The projected target concentrate tonnage level of 1,544,000 swt of concentrate will be online in advance of project year one, 2011, and events could combine to allow a possible increase to 1,729,000 swt. A tonnage level of 1,352,000 swt, was also evaluated; however, 1,544,000 swt is considered to be the most likely long-term future.

- Favorable market conditions for concentrate will prevail with average annual zinc prices fluctuating from a short-term temporary cash market extreme low near $.35 per lb to the more normal price range of $.40–$.57 in most years, as indicated in prices from October 25, 1999 to October 24, 2004.

- Short period price downturns will find the trough of zinc prices above Red Dog Mine long-term break-even price of $.305/lb in 2004, and the 1998–2004 price adjusted average of $.355/lb.

This will be under the operating margin for half of the other mines in production world-wide, and therefore, such a price condition will lead to a world-wide production slowdown at sub-marginal mines. This will last until world inventories are drawn down and end users competing for depleted stockpiles bid prices higher thus precipitating an increase in production. This scenario is anticipated to be an infrequent cycle with a duration of 3–6 months, and in extremely rare cases, as long as 12–24 months given that some countries may elect to subsidize sub-marginal production for purposes of encouraging fledgling mines or to attract badly needed foreign exchange.

- Federal discount rate of 5 3/8%.
- Reconstructed cost is appropriate as a measure of opportunity cost whereas rates may reflect market anomalies not appropriate as a measure of the cost of the resource being evaluated.
- Fuel prices include all costs of production, therefore fuel purchased while taking advantage of price differentials between U.S. and foreign sources represent a NED savings.
- Where the world deep draft fleet has demonstrated that it is able to provide appropriate vessels without undue delay based on announced need, voyages do not need to account for backhaul or positioning.
- Barge backhaul or positioning will be accounted for when equipment is dedicated to a particular commodity or route or initially mobilized from a distant location.
- Lighters similar to those now in use will be typical of lighters used in the with-project condition.
- Tendency for petroleum consumption to increase with population growth will be generally offset by conservation measures and/or substitutes.
- Capital already invested in the terminal operation or which will be invested without the proposed project can be treated as a sunk cost with recognition of salvage values as appropriate. Project related savings in future O&M are treated as an avoided cost.
- Given a quantity representing multi-village fuel consumption, use at specific localities can be estimated by allocating the total among the several communities using consumption per employee more appropriately than per capita consumption.
- Vessels in use on any particular route will be the most practical combination of vessel and load yielding the lowest unit cost without a project and with a project.
- Price level used for alternatives was October 2004.

# 15.0 BENEFIT CATEGORIES

**Benefit-Cost Evaluation.** This section brings benefits together for the various plans and presents the benefits by category for each alternative plan. It provides a benefit summary for the plans which survived the early sorting during which numerous other alternatives were considered. For details on the plan formulation process, refer to that section of the main report.

**Evaluation of the Dedicated Tug and Barge Fleet.** The without-project condition is to continue use of the existing tug and self-unloading barge fleet to transfer concentrate to vessels anchored offshore. The annual cost of the fleet was reconstructed using information furnished by TCAK, shipping industry sources, and the U.S. Army Corps of Engineers.

**Dedicated Fleet Tug And Barge Operation Annual Cost**

| Equipment | Annual Cost ($) |
|---|---|
| 2200 Bp | 1,314,600 |
| 3000 Hp | 1,494,200 |
| 3000 Hp | 1,494,200 |
| 4000 Hp | 1,708,400 |
| Barges | 4,451,000 |
| Fleet Cost At Site | 10,462,400 |
| Fleet Administration[137] | 864,300 |
| Fleet Profit[138] | 1,132,700 |
| Reconstructed Cost | 12,459,400 |

The above reconstructed cost is about $2 million short of the amount TCAK actually pays FOSS for the tug and barge service in a year. The un-reconciled difference could be related to un-quantified risk aspects of the shipping agreement or perhaps the presence of costs which do not fit the Corps required reconstructed cost approach and the NED frame of reference.

Foss accepts the financial consequences of not being able to load all of the planned concentrate shipments, and this risk figures into the contract. There may be other risks as well such as equipment damage and potential income losses. However, there is no damage-frequency analysis available to track the reasonableness of this difference between the reconstructed cost and the contract value. Therefore, nothing is included in this economic evaluation to represent it. However, a one-time event affecting the loss of use of both self-unloader units could produce a net income loss in the range of $200–$300 million for just one year.

The alleged risk related to the contract agreement stems from the use of one-of-a-kind, self-unloading barges in an open roadstead offshore transfer operation in a remote arctic location. All of the project alternatives that do away with the tug and barge lightering system would also minimize the loading risk. In these with-project conditions, the self-unloaders are eliminated, and a trestle (or tunnel) with a permanently installed conveyor and shiploaders are provided.

The calculated annual savings in the tug/barge fleet is $12,459,400 and must be adjusted to reflect that the mine is estimated to have a 31-year life remaining after 2011. Using a 5 3/8 %

[137] ITR recommended 12% consistent with IWR data.

[138] Default value based on ITR input, Kevin Horn, Gulf Engineers.

discount rate, the annual benefit has an accumulated present worth of $186,067,300 and an annualized 50-year NED benefit value of **$10,788,300**.

**Deep Draft Shipping Costs and the Simulation Model.** In the tug and barge cost, there is nothing included for tug and barge delay because the shipper is assessed a level annual cost for the season regardless of the minor variations in the time that the fleet is active or idle. Since the equipment is tied up by the Portsite operation and any other earning potential is eliminated, the reconstructed cost to the shipper is taken as representative of opportunity cost as well. Nevertheless, there are delays, and the delays do have effects on other parts of the transportation systems, such as delay caused to the deep draft carriers and restrictions on throughput of the terminal, both of which are treated as separate NED issues.

The simulation model has two purposes:

- To estimate the deep draft vessel queue that will develop without a project and with each of the alternatives. When coupled with vessel operating, cost this data can be used to estimate delay reduction benefits.

- To estimate how much concentrate the without-project condition and each alternative project can deliver given a specific mine production target (most likely production target of 1,544,000 swt annually). When coupled with production and shipping cost, this can be used to estimate induced tonnage benefits.

The model makes a number of Monte Carlo decisions including a determination of the first possible shipping day and the last possible shipping day of the season. These decisions are linked to satellite data pertaining to ice coverage. Within this shipping window, it then calculates the number of ships needed during the season and makes a Monte Carlo selection of each ship arrival time and the size of ship. As each ship arrives, it uses docking parameters to calculate the time it takes to move the ship to an anchorage or to the trestle, and then, it applies other time and activity parameters to see that the ship is attended to by a tug and barge for purposes of loading.

This is described as a queuing model, so has a built in clock function. At each hour of the shipping season, the model refers to wind and wave data, and uses threshold decision criteria to determine if the barges can be loaded. This hourly operating decision is the basis for estimating all vessel delay, and it is also an important determinant of annual throughput. In both calculations *Weather Days* and *Weather Delays to Vessels in Port* are important outputs.

**Weather Days**. The ship simulation model is designed to identify and account for the time and throughput impact of weather when loading barges at the dock. It also identifies the time and throughput impact of weather when loading from the barges onto ships at the deep draft anchorage. These impacts can be either a stoppage of loading and unloading or a resumption of loading and unloading.

For interruptions to barge loading, the threshold event would be weather and/or wind adequate to cause barge movement at the dockside equivalent to the severity of movement that the barge would have in a wave of about 1 meter in open water. For interruption to ship loading, this would be weather and wind adequate to cause differential barge-ship movement, experienced at the ship side equivalent to the severity of movement that the barge would have in the lee of the ship during a wave of about 2 meters in open water.

**Weather Delay to Vessels in Port.** The simulator looks at the wind and wave environment each hour and determines if the weather is severe enough to cause an interruption of the barge operation. If an interruption is required the simulator keeps track of the time the barge is out of service and does not allow it to resume loading until the weather conditions subside. These weather events actually delay both the barge and the deep draft vessel—the barge, because loading is interrupted, and the deep draft vessel, because each hour the barge loading is delayed is an hour longer that the deep draft vessel must stay in port.

**Model Verification.** The model was verified by checking to see if it could replicate the *Weather Delays to Vessels in Port* that were known to actually occur and which could be verified by reliable historical data without unreasonably distorting other parameters such as total weather days or tonnage throughput. For this verification, actual records for the shipping years of 1997 and 1998 were selected. These years had very similar throughput, and the mine and shipping system underwent no major modifications or changes during this time period. These years had weather delay days to vessels in port of 13 and 17 days, respectively, and historical production of 1,086,572 tons and 1,070,735 tons, respectively.

In the model, *Total Weather Days* are days when the weather is bad enough (wind, wave, current) to stop loading, whether a barge is present or not. It is merely an inventory of the amount of time during the ice free season that days could not be used for loading, regardless of whether loading is or is not needed. This is in contrast to *Weather Delays to Vessels in Port*, which are days when loading is underway and would be interrupted because of the weather day. Only the later is directly tied to benefits.

The model arrives at *Total Weather Days* and *Weather Delays to Vessels in Port* probabilistically, using wind, wave, and current data drawn from 16 years of data. The weather data was based on an actual 16-year record augmented with severe historic storms reaching back as far as 1954. This augmented dataset was disaggregated to hourly wind, wave, current and then localized to Portsite by calibrating the model to replicate the number of weather days actually recorded in 1997 and 1998. After the calibration, the model was run to simulate the Portsite tug/barge operation hourly, serially repeating the dataset to approximate a 50-year evaluation period.

The purpose of the calibration is to test whether the model can reproduce what we can say happened historically. If it can reasonably replicate a year or two of historic data, then we are more comfortable in using it as a predictive/analytic tool. The calibration of probabilistic models does not rest on attempts to exactly reproduce a historic year or to exactly reproduce a historic year as an average of simulation years. The calibration exercise includes the use of judgment, and many experienced simulation modelers go so far as to refer to it as an "art" comparable to some aspects of hydrologic models. Typically, as in this case, calibration rests on ground-truth for a fairly narrow selection of data, which has broad implications to the overall model validity and application. This focus, on a critical output reference, is necessary, because there are usually numerous variables within probabilistic models and many variables outside of them, all taking place somewhat randomly. The calibration of better known applications, such as system hydropower models and basin hydrologic models, do not depend on verification being an exact duplication of a historic data year.

The model was tested to see if it can reasonably recreate critical characteristics of a known event or events relating to a historic year. In this study the shipping simulation model output was compared to actual 1997 and 1998 data, seeking reasonable verification, accompanied by explanations of variations. The calibration test tended to focus model development in the direction of reproducing the *Weather Delays to Vessels in Port*. Model calibration, based on other measures, was discussed, such as total weather days, gap days, and weather excluded days between vessels. None of them, however, were as directly tied to calculation of benefits as *Weather Delays to Vessels in Port*, and some of the others had problems with data interpretation.

For example, *Total Weather Days* was considered as a calibration measure and rejected, because the data for identifying *Total Weather Days* changed over time. The simulator's count of the *Total Weather Days* is based on a threshold weather event (wind, current, wave) adequate to cause barge movement at the dock equivalent to the severity of movement that the barge would have with a 1 meter of wave in open water. This is in contrast to the historic *Total Weather Days* which is keyed to a dockside threshold (assumed) as a 1 meter wave. So, the 1998 and 1997 thinking at the time, and observations on record, were keyed to that "actual interpretation" of the wave at the site.

We, therefore, have 1997–1998 observations (no actual hourly real time at-site instrumented and documented vessel movement gage records) from qualified experts keyed to the 1 meter wave assumption. The 1 meter assumption was studiously derived from early open water sea-keeping criteria for the vessels. However, it was later at-site observations of a reflected wave situation and more understanding of at-site vessel behavior that revealed the limiting wave at dockside was equivalent to a 1 meter wave in deeper, more open water, and consequently, somewhat less than 1 meter dockside. Clearly one would engage a great deal of difficulty in attempts to calibrate the model to *Total Weather Days* information.

Recognizing that the context of *Total Weather Days* is incongruent, the focus of the calibration swings to replication of *Weather Delays to Vessels in Port*. Fortunately, there is actual data for *Weather Delays to Vessels in Port*, and it is used as direct input to the benefit evaluation. The simulator makes a very close reproduction of the two test years.

The model runs hourly wind, current, and wave data, and if the conditions are bad enough to terminate loading or to postpone it, the duration of the limiting condition becomes part of a weather day. If there is loading in progress or ready to start and the limiting conditions cause it to stop or get postponed, the time starts to be counted as a day of *Weather Delays to Vessels in Port*.

The simulator uses hourly wind data, but it also includes a 6-hour look ahead adjustment. Ships are not dispatched to the berth, if the following conditions occur within the next six hours:

- Wind equal to or greater than 35 knots.
- Current equal to or greater than one knot.
- Waves equal to or greater than 2 m.

The six-hour look ahead also applies similar logic to the barge loading operation. If bad weather is forecast, then barge loading is not started. Therefore, for this reason one should expect that there would be more time of bad weather when berths are not occupied than bad weather when they are occupied.

In the calibration exercise, a tonnage target was set at the amount known to have been actually shipped in each test year. For verification, the model was also provided with the actual ship mix that occurred in 1997 and 1998 and then allowed to cycle serially, by hour, through the weather data while the wave threshold which dictated the barge and ship loading interruption was varied in increments of .1 meter. Reviewing the output files, it was found that setting the hourly decision criteria at a wave of .4 meters produced the following results:

**Table 73. Calibration**

| | 1998 actual | 1998 Simulate >. 4 m Waves | 1997 actual | 1997 Simulate >. 4 m Waves |
|---|---|---|---|---|
| Weather Delays to Vessels in Port | 17 | Different years ranged from 16.2–20.5, average was 18 | 13 | Different years ranged from 11.7–13.7, average was 13 |

The vessel fleet mix is an important simulation input, and there are subsets of the fleet expectation that are model drivers, such as average load, expected vessel size distribution, load rate, and probability of arrival. The manner, in which the simulator blends the random or probabilistic aspects of these inputs with the hourly weather and wind data, results in the number of vessels and mix of vessels not being exactly the same every year. The simulator expresses the results as an average of all of the years modeled, and the average is used to calculate the benefits.

Vessel operating costs are an external parameter and are applied to the model output in terms of cost per day and cost per ton, carried in a specific type of vessel to calculate the benefits. In different time frames, the shipping cost for identical trips can vary because loads and ships may not be identical. Deep draft shipping cost is simulated separately for each alternative to determine the frequency and duration of barge and ship loading interruptions by looking at the operations hourly.

As an example of some other inputs used by the model and also by the benefit calculation, the deep draft shipping cost is derived from the following primary inputs:

- Fleet distribution is 20 Panamax and 6 Handysize, for the without-project condition and varying for different alternatives.
- Cost ton/day of $.265 for Panamax and $.366 for Handysize, loaded 85.5% and 90% of dwt respectively.
- Annual tons 87% Panamax and 13% Handysize.
- Voyage days are 27 for Panamax and 14 for Handysize.
- Specified immersion rates.
- Distribution of arrival dates (one distribution based on regularly spaced arrivals plus or minus two days; a second schedule based on arrivals varying from one day early to four days late).
- Start and end for each year based on satellite observations of ice cover within the limits of historical shipping seasons.

- 4 evenly spaced tanker calls with one at the beginning of the season and one at the end. Tanker loads are 14,686,700 gallons (55,000 dwst capacity tanker loaded to 49,935, say 44,930) and simulation output is generally unaffected by an increase in shipments. At around 16,176,000 gallons, an adjustment would be made to a larger tanker; however, it would still be operational within the draft constraints of the project.

- Hourly wave and wind data.

For purposes of benefit evaluation, relevant costs are those which are changed due to a proposed plan. There are no changes in the bulk carrier fleet, origins, or destinations, and this consistency among conditions removes the need to deal with costs associated with some parts of the shipping cycle and removes the need to incorporate route specific details, dealing with time at sea and cost at destination ports. Where a proposed plan is effective at increasing the amount of tonnage shipped, it is credited with a benefit for "induced tonnage" described separately.

The simulator is used to establish the annual tonnage shipped, the number of weather days, the amount of vessel delay to vessels in port, number of vessels, and days in queue; these output variables change depending on the plan under consideration. Each of the dependent variables has a particular link to the benefit evaluation as noted below:

- Weather delays to vessels in port are evaluated, based on the number and mix of vessels delayed and the average cost per day in port.

- Days in queue are evaluated, based on the number and mix of vessels calling (to the nearest whole vessel), the number of days (including fractional days), and the average daily cost in port.

- Transit cost of vessels is evaluated, based on the number and mix of vessels their average trip travel time and cost per day at sea.

- Induced tonnage is determined, by tonnage shipped over tonnage of the without-project condition up to the target throughput level, and is evaluated, based on willingness to pay.

The simulator incorporates a queuing sub-routine which tallies the time for all vessels in queue during a season. Delay time will vary with target throughput, weather conditions, and equipment used. In the following table, the cost of weather delay at the dock and any queuing effect are combined. Detail on delay and queue are shown in the section of this report dedicated to discussion of the simulator.

**Table 74. Benefit For Cost In Port, Includes Queue Using 1,544,000 swt Target Projection**

| Case | Pax Calls | Pax Days | Pax Cost @ $12,252 ($000) | Hdy calls | Hdy Days | Hdy Cost @ $10,160 ($000) | Cost Total ($ 000) | Cost Diff ($ 000) | Equiv Ann Benefit ($000) |
|---|---|---|---|---|---|---|---|---|---|
| W/O | 20 | 318 | 3,896.1 | 6 | 95 | 965.2 | $4,861.3 | N/A | |
| Alt 2 – 3 Barges | 21 | 229 | 2,805.7 | 5 | 65 | 660.4 | 3,466.1 | 1,395.2 | 1,208.1 |
| Alt 3 – BW | 20 | 102 | 1,249.7 | 6 | 31 | 315.0 | 1,564.7 | 3,296.6 | 2,854.5 |
| Alt 4 – 3 Barge & BW | 20 | 78 | 955.7 | 6 | 23 | 233.7 | 1,189.4 | 3,671.9 | 3,179.4 |
| Alt 5 –CH+TR (w/o F) 139 | 20 | 63 | 771.9 | 6 | 19 | 193.0 | 964.9 | 3,896.4 | 3,373.8 |
| Alt 6 – CH+TU (w/o F) 139 | 20 | 63 | 771.9 | 6 | 19 | 193.0 | 964.9 | 3,896.4 | 3,373.8 |
| Alt 7 – OF | 20 | 318 | 3,896.1 | 6 | 95 | 965.2 | 4,861.3 | 0 | 0 |
| Alt 8 – OF+3B | 21 | 229 | 2,805.7 | 5 | 65 | 660.4 | 3,466.1 | 1,395.2 | 1,208.1 |
| Alt 9 – OF+BW | 20 | 102 | 1,249.7 | 6 | 31 | 315.0 | 1,564.7 | 3,296.6 | 2,854.5 |
| Alt 10 - OF+3B+BW | 20 | 78 | 955.7 | 6 | 23 | 233.7 | 1,189.4 | 3,671.9 | 3,179.4 |
| Alt 11-CH+TR (w/F) | | | | | | | | | |
| 47' CH | 25 | 75 | 918.9 | 6 | 18 | 182.9 | 1,101.8 | 3,759.5 | 3,255.2 |
| 50' CH | 22 | 66 | 808.6 | 7 | 21 | 213.4 | 1,022.0 | 3,839.3 | 3,324.4 |
| 53' CH | 20 | 66 | 808.6 | 6 | 20 | 203.2 | 1,011.8 | 3,849.5 | 3,333.2 |
| Alt 12-CH+TU (w/F) | 20 | 66 | 808.6 | 6 | 20 | 203.2 | 1,011.8 | 3,849.5 | 3,333.2 |

**Table 75. Benefit For Cost In Port Includes Queue Using 1,729,000 Tons Target Projection**

| Case | Pax Calls | Pax Days | Pax Cost @ $12,252 ($000) | Hdy calls | Hdy Days | Hdy Cost @ $10,160 ($000) | Cost Total ($ 000) | Cost Diff ($ 000) | Equiv Ann Benefit ($000) |
|---|---|---|---|---|---|---|---|---|---|
| W/O | 22 | 442 | 5,548.0 | 5 | 100.5 | 1,021.1 | 6,569.1 | N/A | N/A |
| Alt 2 –3 Barges | 23 | 320 | 3,920.6 | 6 | 83 | 843.3 | 4,763.9 | 1,805.2 | 1,563.1 |
| Alt 3 – BW | 23 | 138 | 1,690.8 | 6 | 36 | 365.8 | 2,056.6 | 4,512.5 | 3,907.3 |
| Alt 4 – 3 Barge & BW | 21 | 82 | 1,004.7 | 10 | 39 | 396.2 | 1,400.9 | 5,168.1 | 4,474.9 |
| Alt 5 – CH+TR (w/o F) [139] | 23 | 71 | 869.9 | 6 | 18 | 182.9 | 1,052.8 | 5,516.3 | 4,776.4 |
| Alt 6 – CH+TU (w/o F) 139 | 23 | 71 | 869.9 | 6 | 18 | 182.9 | 1,052.8 | 5,516.3 | 4,776.4 |
| Alt 7 – OF | 22 | 442 | 5,548.0 | 5 | 100.5 | 1,021.1 | 6,569.1 | 0 | 0 |
| Alt 8 – OF+3B | 23 | 320 | 3,920.6 | 6 | 83 | 843.3 | 4,763.9 | 1,805.2 | 1,563.1 |
| Alt 9 – OF+BW | 23 | 138 | 1,690.8 | 6 | 36 | 365.8 | 2,056.6 | 4,512.5 | 3,907.3 |
| Alt 10 - OF+3B+BW | 21 | 82 | 1,004.7 | 10 | 39 | 396.2 | 1,400.9 | 5,168.1 | 4,474.9 |
| Alt 11-CH+TR (w/F) | | | | | | | | | |
| 47' CH | 28 | 78 | 955.7 | 5 | 14 | 142.2 | 1,097.9 | 5,471.2 | 4,737.4 |
| 50' CH | 25 | 72 | 882.1 | 6 | 17 | 172.7 | 1,054.8 | 5,514.3 | 4,774.7 |
| 53' CH | 23 | 74 | 906.6 | 6 | 19 | 193.0 | 1,099.6 | 5,469.5 | 4,735.9 |
| Alt 12-CH+TU (w/F) | 20 | 66 | 808.6 | 6 | 20 | 203.2 | 1,011.8 | 3,849.5 | 3,333.2 |

**Concentrate Vessel Transit Cost**. With or without the project, the destinations for the concentrate carriers are the same. However, some of the alternative plans have an affect on the number of vessels required to ship the concentrate, such as a shallower channel, which would decrease the allowable vessel size and increase the number of vessels accordingly. The total cost of vessels will change as the number of vessels and size of vessels change. The number of vessels and the mix are obtained from the simulation results and incorporated in the following summary table.

[139] Queue impact calculated external to simulation model. Transfer rate is 30,000 bbl/hr, 10" – 12" pipe, 125 psi, from Army Field Manual 10-67, Chapter 2 accessed at http://www.globalsecurity.org/military/library/policy/army/fm/10-67/index.html. 12 hr transfer + 12 Hr activity allowed = 24 hr turn around x 4 calls allocated by # HANDY and PMAX calls (80-20.)

Some of the alternative plans result in the shipping of more tons because of higher levels of efficiency. The increased tonnage is counted elsewhere as "induced tonnage." Higher tonnage levels generally require a larger number of vessels so the overall transit cost is actually higher with some alternative plans than it is in the without-project condition thereby creating a "negative benefit" when this aspect of the evaluation is viewed separate from everything else.

The average number of days in transit is 27 for Panamax vessels and 14 for Handysize. The trip durations are an average of all sailings from Portsite over the 1996–1999 four year period. Only transit days, to the first destination of multiple calls, were included. The extent to which vessel itineraries to the second and third ports of call are affected by the various alternative plans is unknown so travel times were not included. About 37% of the Portsite departures have a second destination and about 17% have a third call. Including the entire trip time from Portsite to the last port of call is investigated in the sensitivity analysis in Section 17 of this Appendix.

**Table 76. Benefit For Cost In Transit, Excludes Queue Using 1,544,000 swt Target Projection**

| Case | Pax Calls | Trip Days @ 27 per | Pax Cost $17,448 ($000) | Hdy calls | Trip Days @ 14 per | Hdy Cost @ $14,440 ($000) | Cost Total ($ 000) | Cost Diff ($ 000) | Equiv Ann[140] Benefit ($000) |
|---|---|---|---|---|---|---|---|---|---|
| W/O = | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | N/A | N/A |
| Alt 2- 3 Barge | 21 | 567 | 9,893.0 | 5 | 70 | 1,010.8 | 10,903.8 | (268.9) | (232.9) |
| Alt 3 - BW | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 4 - 3 Barge and BW | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 5 – CH+TR (w/o F) | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 6 – CH+TU (w/o F) | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 7 – OF | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 8 – OF+3B | 21 | 567 | 9,893.0 | 5 | 70 | 1,010.8 | 10,903.8 | (268.9) | (232.9) |
| Alt 9 – OF+BW | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 10 - OF+3B+BW | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 11-CH+TR (w/F) | | | | | | | | | |
| 47' CH | 25 | 675 | 11,777.4 | 6 | 84 | 1,213.0 | 12,990.4 | (2,355.5) | (2,039.9) |
| 50' CH | 22 | 594 | 10,364.1 | 7 | 98 | 1,415.1 | 11,779.2 | (1,144.3) | (991.0) |
| 53' CH | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |
| Alt 12-CH+TU (w/F) | 20 | 540 | 9,421.9 | 6 | 84 | 1,213.0 | 10,634.9 | 0 | 0 |

[140] Transit cost effects are realized over a 31 year period of the 50-year project economic life and are adjusted in this column to reflect a 50-year equivalent annual value at 5.375%.

**Table 77. Benefit For Cost In Transit, Excludes Queue Using 1,729,000 Tons Target Projection**

| Case | Pax Calls | Trip Days @ 27 per | Pax Cost $17,448 ($000) | Hdy calls | Trip Days @ 14 per | Hy Cost $14,440 ($000) | Cost Total ($ 000) | Cost Diff ($ 000) | Equiv Ann Benefit ($000) |
|---|---|---|---|---|---|---|---|---|---|
| W/O = | 22 | 594 | 10,364.1 | 5 | 70 | 1,010.8 | 11,374.9 | N/A | N/A |
| Alt 2 – 3 Barge | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |
| Alt 3 - BW | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |
| Alt 4 - 3 Barge and BW | 21 | 567 | 9,893.0 | 10 | 140 | 2,021.6 | 11,914.6 | (539.7) | (467.4) |
| Alt 5 – CH+TR (w/o F) | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |
| Alt 6 – CH+TU (w/o F) | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |
| Alt 7- OF | 22 | 594 | 10,364.1 | 5 | 70 | 1,010.8 | 11,374.9 | 0 | 0 |
| Alt 8 - OF+3B | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |
| Alt 9 – OF+BW | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |
| Alt 10 – OF + 3B + BW | 21 | 567 | 9,893.0.1 | 10 | 140 | 2,021.6 | 11,914.6 | (539.7) | (467.4) |
| Alt 11 – CH+TR (w/F) | | | | | | | | | |
| T-C 47' | 28 | 756 | 13,190.7 | 5 | 70 | 1,010.8 | 14,201.5 | (2,826.6) | (2,447.8) |
| T-C 50' | 25 | 675 | 11,777.4 | 6 | 84 | 1,213.0 | 12,990.4 | (1,615.5) | (1,399) |
| T-C 53' | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |
| Alt 12 – CH+TU (w/F) | 23 | 621 | 10,835.2 | 6 | 84 | 1,213.0 | 12,048.2 | (673.3) | (583.1) |

**Induced Tonnage.** An NED benefit, referred to as "induced," is derived from the increased production tonnage which is possible because of the effects of a project. In the case of Red Dog Mine, the production is constrained by the throughput capacity of the shipping system, in the sense, that the mine output has no value if it cannot be delivered to a customer. In addition there is also the specter of unrealized income and added storage cost plus the inconvenience of a customer's experience with production loss and quite possibly the unwelcome vision of a higher cost substitute source.

The simulator calculates tons shipped, as an average annual value, running 16 years of weather data on an hourly basis. Simulation runs were made for 6 of the cases, and findings were transferred to other similar cases. Data transfer was used in lieu of simulation runs where it was evident that the alternatives were not worthy candidates for the NED plan selection. This was an evaluation choice, based on minimizing study cost for inconsequential issues having no bearing on the outcome.

Benefits are realized over 31 years of the 50-year project economic life, reducing the annual value to .866%. Refer to the report section on Induced Tonnage for an explanation of the benefit evaluation. The annual tonnage and benefits are:

**Table 78. Benefit For Induced Tons Using 1,544,000 swt Target Projection**

| Case | Potential Tons Shipped | W-W/O Limited by 1,544,000 | Benefit Value ($) |
|---|---|---|---|
| W/O | 1,520,519 | - | - |
| Alt 2-3 Barges | 1,570,664 | 23,481 | 1,707,900 |
| Alt 3-BW | 1,575,700 | 23,481 | 1,707,900 |
| Alt 4-3 Barges and BW | 1,575,569 | 23,481 | 1,707,900 |
| Alt 5-CH+TR (w/o F) | 1,575,700 | 23,481 | 1,707,900 |
| Alt 6-CH+TU(w/o F) | 1,575,700 | 23,481 | 1,707,900 |
| Alt 7-OF | 1,520,519 | 0 | |
| Alt 8-OF+3B | 1,570,664 | 23,481 | 1,707,900 |
| Alt 9- OF+BW | 1,575,700 | 23,481 | 1,707,900 |
| Alt 10-OF+3B+BW | 1,575,569 | 23,481 | 1,707,900 |
| Alt 11-CH+TR (w/F) | | | |
| CH+TR 47 ft | 1,571,669 | 23,481 | 1,707,900 |
| CH+TR 50 ft | 1,574,219 | 23,481 | 1,707,900 |
| CH+TR 53 ft | 1,573,838 | 23,481 | 1,707,900 |
| Alt 12-CH+TU (w/F) | 1,573,838 | 23,481 | 1,707,900 |

**Table 79. Benefit For Induced Tons Using 1,729,000 Tons Target Projection**

| Case | Tons Shipped | W-W/O Limited by 1,729,000 | Benefit Value ($) |
|---|---|---|---|
| W/O | 1,628,654 | - | - |
| Alt 2-3 Barges | 1,727,389 | 98,735 | 7,182,000 |
| Alt 3-BW | 1,759,506 | 100,346 | 7,299,200 |
| Alt 4-3 Barges and BW | 1,758,504 | 100,346 | 7,299,200 |
| Alt 5-CH+TR (w/o F) | 1,762,187 | 100,346 | 7,299,200 |
| Alt 6-CH+TU(w/o F) | 1,762,187 | 100,346 | 7,299,200 |
| Alt 7-OF | 1,628,654 | - | |
| Alt 8-OF+3B | 1,727,389 | 98,735 | 7,182,000 |
| Alt 9- OF+BW | 1,759,506 | 100,346 | 7,299,200 |
| Alt 10-OF+3B+BW | 1,758,504 | 100,346 | 7,299,200 |
| Alt 11-CH+TR (w/F) | | | |
| CH+TR 47 ft | 1,755,748 | 100,346 | 7,299,200 |
| CH+TR 50 ft | 1,756,385 | 100,346 | 7,299,200 |
| CH+TR 53 ft | 1,762,187 | 100,346 | 7,299,200 |
| Alt 12-CH+TU (w/F) | 1,762,187 | 100,346 | 7,299,200 |

The induced tons benefit shown above is for net income effects over 31 years. The mine life is estimated at 40-years, using an extraction rate of 1,544,000 swt; a higher extraction rate would reduce that. Given that there is (1) potential for additional discoveries that would extend the mine life and (2) the minimal effect of adjusting the mine life down by three years to accommodate the effects of shipping 1,729,000 swt and (3) the fact that the higher output level does not enter into the economics of the NED plan, a consistent 40-year life is used.

**Fuel Delivery**. Under the without-project condition, the ocean going barges will continue to offload about a million gallons at Kotzebue, the barges will be lightened enough to offload the balance of a 5,250,000 gallon load at Portsite. This procedure allows six barge loads to deliver the annual 7,750,000 gallons needed at Kotzebue, plus the 25,712,900 gallons needed at Portsite.

For villages not served via Kotzebue, some are served directly by ocean going delivery barge and others are served through fuel terminals at Nome and Bethel. With the project, fuel is delivered by deep draft tanker to Portsite and redistributed from there.

**Table 80. Summary Of Effects, Fuel Transportation**

| Item | Cost W/O Project ($) | Cost With Project ($) | Difference ($) |
|---|---|---|---|
| Delivery to Portsite and Kotzebue+Satellites | 3,290,600 | 1,030,700 | |
| 149,200 | 2,110,700 | | |
| Cost to Nome+Satellites | 1,024,600 | 340,500 | 684,100 |
| Village Direct | 298,800 | 40,900 | 257,900 |
| Swing Villages | 1,318,400 | 231,500 | 1,086,900 |
| Yukon Villages | 531,200 | 531,200 | 0 |
| 7 Yukon Swing Villages | Base | 167,800 delta | 167,800 |
| Lighters | 269,000 | 214,700 | 54,300 |
| Fuel Cost | Base value w/o | -8,812,000 delta | 8,812,000 |
| Total | | | 13,173,700 |

Adjusting the $13,173,700 fuel delivery savings for effective dates and mine life, results in an equivalent annual benefit of **$11,002,400**. This includes a 46-year annual savings for villages of $5,984,400; and a 31-year annual savings of $5,019,000 to the mine (see page ??? for details). Village benefits are not anticipated to be fully realized until the project's fourth year of operation, due to the need to develop a regional delivery system.

**Avoided Cost.** The bulk of the avoided cost calculations are in the section that describes the benefits for the avoided tug and barge operation (see section ???). The tug and barge costs were treated separately, because reduction of the cost of the dedicated tug and barge fleet was an initial and paramount motivation that developed into sponsorship for the study. The tug and barge costs also needed to be developed using a cost reconstruction methodology consistent with NED requirements to avoid rate related distortions.

There are other avoided costs which are not included in the tug and barge calculations and which produce some notable savings that have an NED benefit value. These savings crop up due to reduced manpower and associated support costs for the crews that maintain the local transportation system. In the without-project condition, there are larger crew requirements, because there is a larger local tug and barge fleet and these crew require some support in the way of food and lodging which is referred to within the TCAK recordkeeping system as catering and accommodation. A reduction in these costs is a basis for an NED benefit in much the same way as all other benefits represent reductions in cost between the without-project and with-project condition.

The project alternatives that result in avoided catering and accommodation cost are those which reduce the crew cost at Portsite to less than the cost of the without-project condition. This crew cost difference would include only the channel-trestle alternatives, because alternatives, including a third barge, actually add personnel, and alternatives, including the pipeline, also add personnel. The following table shows the third barge alternative, because there is an associated labor cost not already included in the basic tug and barge cost reconstruction. Cost per man hour is fully burdened based on TCAK records.

**Table 81. Avoided Cost, Catering And Accommodation**

| | Labor in Without Project Condition | Labor With Channel-Trestle | Avoided With Channel- Trestle | Labor With 3rd Barge | Added Assoc Cost W/3rd Barge |
|---|---|---|---|---|---|
| Direct Labor | | | | | |
| TCAK | 1,070 | 1,498 | | 1,070 | |
| NANA | 552 | 245 | | 552 | |
| FOSS | 0 | 367 | | 0 | |
| Labor Time | 1,622 | 1,743 | | 1,622 | |
| Labor Cost | $745,545 | $801,162 | ($55,617) | $745,545 | $0 |
| Catering Labor For | | | | | |
| TCAK | 1,010 | 1,498 | | 1,070 | |
| NANA | 552 | 245 | | 552 | |
| FOSS | 4,590 | 2,062.5 | | 6,885 | |
| CUSTOMS | n/a | 246 | | n/a | |
| USCG | n/a | 123 | | n/a | |
| Labor Time | 6,212 | 4,174.5 | | 8,570 | |
| Labor Cost | $405,147 | $272,261 | $132,886 | $554,827 | $149,680 |
| Column Total | $1,150,692 | $1,073,423 | | $1,300,417 | |
| Rounded | $1,150,700 | $1,073,400 | $77,300 | $1,300,400 | $149,700 |

In order for the avoided costs to be comparable to project benefits, they need to be converted to equivalent annual values over the 50-year project economic life. The savings take place, during a span of 31 years beginning in 2011, so the appropriate factor is .866, and the resulting equivalent annual avoided cost benefit is **$66,900**; the added associated cost in equivalent annual terms is **$129,600.**

**Summary of Plan Comparison.** The following table shows equivalent annual benefits for each of the alternatives carried forward. The benefits are the difference, when compared to the without-project condition. Where positive numbers are shown, there is a beneficial effect, compared to the without-project condition, and where numbers are in parentheses the effect is adverse.

The table shows benefits associated with a target shipping level of 1,544,000 swt. Other tonnage levels were evaluated, and an alternative projection of 1,729,000 swt was designated as a possible but less probable future. The higher tonnage level would change the benefit evaluation for all categories, raising the total benefit for all plans but would not change the order of their accomplishments. The effect of the alternative tonnage level on the benefit calculation is summarized in the sensitivity analysis section of this report.

**Table 82. Annual Benefits Of Alternative Plans Nominal 2004 Price Level ($Thousands)**

| Alternative | Tug and Barge Cost | Port and Queue | Vessel Transit | Induce Tons | Fuel | Avoid Cost | Total Annual Benefit |
|---|---|---|---|---|---|---|---|
| Alt 2 – 3rd Barge | 0 | 1,208.1 | (232.9) | 1,707.9 | 0 | (129.6) | 2,553.5 |
| Alt 3 – BW | 0 | 2,854.5 | 0 | 1,707.9 | 0 | 0 | 4,562.4 |
| Alt 4 – 3rd B & BW | 0 | 3,179.4 | 0 | 1,707.9 | 0 | (129.6) | 4,757.7 |
| Alt 5 – CH+TRS (w/o F) | 10,788.3 | 3,373.8 | 0 | 1,707.9 | 0 | 66.9 | 15,936.9 |
| Alt 6 – CH + TUN (w/o F) | 10,788.3 | 3,373.8 | 0 | 1,707.9 | 0 | 66.9 | 15,936.9 |
| Alt 7 – OF | 0 | 0 | 0 | | 11,002.4 | 0 | 11,002.4 |
| Alt 8 – OF + 3B | 0 | 1,208.1 | (232.9) | 1,707.9 | 11,002.4 | (129.6) | 13,555.9 |
| Alt 9 – OF + BW | 0 | 2,854.5 | 0 | 1,707.9 | 11,002.4 | 0 | 15,564.8 |
| Alt 10 – OF +3B+BW | 0 | 3,179.4 | 0 | 1,707.9 | 11,002.4 | (129.6) | 15,760.1 |
| Alt 11 – CH + TRS (w/F) | | | | | | | |
| 47' channel | 10,788.3 | 3,255.2 | (2,039.9) | 1,707.9 | 11,002.4 | 66.9 | 24,780.8 |
| 50' channel | 10,788.3 | 3,324.4 | (991.0) | 1,707.9 | 11,002.4 | 66.9 | 25,898.9 |
| 53' channel | 10,788.3 | 3,333.2 | 0 | 1,707.9 | 11,002.4 | 66.9 | 26,898.7 |
| Alt 12 – CH +TUN (w/F) | 10,788.3 | 3,333.2 | 0 | 1,707.9 | 11,002.4 | 66.9 | 26,898.7 |

**Price Level.** A draft Economics Appendix was prepared, using the latest data available, during year 2002. After an internal agency technical review completed in 2004, the economic analysis was updated. The basic economic data upon which the benefits are based is as follows:

- 2004 for cost of deep draft vessels, including machinery, labor, and bunker fuel.
- 2003 for ocean towing equipment and ocean barges, including labor, machinery, and fuel.
- 2003 for the dedicated tug and barge fleet, including machinery, labor, and diesel fuel.
- 2003 for lighters including machinery, labor, and diesel fuel.
- 2002 for avoided cost.

Year 2004 is the price level on which the costs are based. Benefits and costs need to be in the same units, so a review was made of how price level adjustments would affect the benefits if expressed in 2004 prices. This was done by review of the Gross Domestic Product (GDP) Price Deflator. The GDP is the monetary value of all the goods and services produced by an economy over a specified period. It includes consumption, government purchases, investments, and exports minus imports. The GDP Price Deflator is an economic metric used to account for inflation by converting output measured at current prices into constant-dollar GDP. The GDP deflator shows how much of the change in the GDP from a base year is reliant on changes in the price level. It essentially compensates for productivity changes by isolating them from price effects. This index is appropriate in this economic evaluation because none of the benefit categories depend on a projection of future economic growth, population expansion, or productivity.

The GDP index is .98 for mid 1999; 100 for mid 2000; 102 for mid 2001; 104 for mid 2002; 107 for mid 2003; and 107.5 for mid 2004. The overall adjustment from 2003 to 2004 was under 1% and so was deferred.

# 16.0 ANNUAL COST AND NED PLAN

**Annual Costs.** Each of the alternative plans has unique attributes that express themselves as variations in the conversion of cost estimates to equivalent annual values. Among them are:

- The construction schedule and rate of expenditure, both of which combine to create variations in interest during construction. Compound interest is calculated, based on mid-year average expenditure conventions.
- The amount of annual operation and maintenance cost varies among all plans.
- The amount of maintenance; dredging and the dredging interval varies with the depth and length of the channels for the different alternatives.

Standard discounting procedures are used to annualize the costs over a 50-year period, using 5 3/8%. Results of the calculations are summarized in the following tables with all costs equivalent to October 2004 price levels. The tables are organized from front to back in series following the 12 alternatives.

Following the summary cost tables, for each of the alternatives, is a set of cost tables relating only to the trestle element. These tables illustrate cost differences that result from variations in length of the trestle.

Where the channel is a part of any of the alternatives, it is included consistently at the maximum depth considered, 53 ft. This was done during the planning process to keep the various alternatives equivalent and consistent. Late in the planning, many pieces of material came together to indicate, under some assumptions, the NED depth of channel narrowly favored 53 ft, while with other assumptions, 53 ft had a wide margin, making it a clear and unambiguous choice.

**Depth Considerations, Cost Implications, and NED plan**. With regard to the array of alternatives, the economic order is the same regardless of channel depth considerations. The depth consideration is merely a refinement of one alternative. Where a channel is included as a plan element, other aspects (tunnel or trestle for example) overwhelm cost of the channel at any depth. Relative to the cost of other plan elements, cost savings from varying the channel depth are less significant. However, there are measurable benefit and cost tradeoffs associated with varying the channel depth. After demonstration that the channel-trestle concept, embodied in Alternative 11, held the most promise for becoming the NED plan, a channel depth optimization comparison illustrated that a depth of 53 ft provides maximum NED net benefits. Variations in the mix of trestle length and channel length were also tested with net benefit criteria, and a trestle of 1,450 ft provided the maximum net benefits in combination with a 53 ft channel. The following tables summarize the cost of the various alternatives.

**Table 83. Alternative 2, 3rd Barge**

| | 2008 | 2009 | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost (Barge & Tug) | | | 19,200,000 | 19,200,000 |
| PW of T&B Replacement @ year 25 | | | 4,823,100 | 4,823,100 |
| Mitigation | | | 0 | 0 |
| Subtotal | | | 24,023,100 | 24,023,100 |
| | | | | |
| Planning/Engineering/Design[141] | | | | |
| Construction Management | | | | |
| Lands and Damages | | | | |
| Subtotal | | | 24,023,100 | 24,023,100 |
| | | | | |
| Navigational Aids (USCG) | | | 0 | 0 |
| Subtotal First (Capital) Cost | | | 24,023,100 | 24,023,100 |
| | | | | |
| IDC[141] | | | | 323,500 |
| Total Investment Cost | | | | 24,346,600 |
| Annualized Investment | | | | 1,411,631 |
| OMRR&R | | | | 2,325,200 |
| | | | | |
| **Annual Cost** | | | | **3,736,831** |

**Table 84. Alternative 3, Breakwater**

| | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost | 18,187,783 | 18,187,783 | 18,187,783 | 54,563,348 |
| Mitigation | 27,789 | 0 | 3,572,211 | 3,600,000 |
| Bypass Dredging Mitigation | 0 | 0 | 325,000 | 325,000 |
| Subtotal | 18,215,571 | 18,187,783 | 22,084,994 | 58,488,348 |
| | | | | |
| Planning/Engineering/Design 7.5% | 1,366,168 | 1,364,084 | 1,656,375 | 4,386,626 |
| Construction Management 11.5% | 2,094,791 | 2,091,595 | 2,539,774 | 6,726,160 |
| Lands and Damages | 13,318 | 0 | 0 | 13,318 |
| Subtotal (GNF Costs) | 21,689,848 | 21,643,461 | 26,281,143 | 69,614,452 |
| Navigational Aids (USCG) | 0 | 0 | 25,000 | 25,000 |
| Subtotal | 21,689,848 | 21,643,461 | 426,306,143 | 69,639,452 |
| | | | | |
| IDC | 3,031,250 | 1,768,247 | 697,725 | 5,497,222 |
| Total Investment Cost | | | | 75,136,674 |
| Annualized Investment | | | | 4,356,470 |
| OMRR&R | | | | 425,153 |
| | | | | |
| Annual Cost | | | | 4,781,623 |

[141] Suitable tugs are available on the world market (see Marcon International database). Barge hulls are also available. Mechanical loader is already available as a spare. Barge hull modification and equipment refit is estimated at six months, allowing for relocation to west coast U.S. PED and construction management is included in cost of the unit based on total cost of sister units.

**Table 85. Alternative 4, Breakwater And 3rd Barge**

| | Cost ($) |
|---|---|
| **Breakwater** | |
| Total Investment | 75,136,674 |
| Annualized Investment | 4,356,470 |
| OMRR&R | 425,153 |
| Breakwater Annual Cost | 4,781,623 |
| | |
| **3rd Barge** | |
| Investment Cost | 24,346,600 |
| Annualized Investment | 1,411,631 |
| OMRR&R | 2,325,200 |
| 3rd Barge Annual Cost | 3,736,831 |
| | |
| **Breakwater And 3rd Barge** | 8,518,454 |

**Table 86. Alternative 5, 53 ft Channel-Trestle (No Fuel)**

| | 2007 ($) | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|---|
| First Cost Trestle | 2,564,500 | 34,620,754 | 61,548,007 | 29,491,753 | 128,225,015 |
| Mitigation Cost | 116,109 | 66,701 | 64,231 | 1,058,559 | 1,305,600 |
| Bypass Dredging Mitigation | 0 | 0 | 0 | 325,000 | 325,000 |
| Owner's Costs | 180,753 | 2,115,556 | 3,756,121 | 1,762,892 | 7,815,322 |
| Lands and Damages | 13,318 | 0 | 0 | 0 | 13,318 |
| Planning/Engineering/Design 4.88% | 130,814 | 1,692,748 | 3,006,677 | 1,506,715 | 6,336,954 |
| Const Mgnt 6.70% | 179,601 | 2,324,059 | 4,128,020 | 2,068,646 | 8,700,326 |
| Subtotal | 3,185,095 | 40,819,819 | 72,503,506 | 32,213,566 | 152,721,535 |
| | | | | | |
| IDC | 637,865 | 5,708,252 | 5,923,419 | 960,502 | 13,230,037 |
| Trestle Investment Cost | | | | | 165,951,573 |
| Annualized Investment | | | | | 9,621,974 |
| OMRR&R | | | | | 6,550,459 |
| Trestle Annual Cost | | | | | 16,172,433 |
| | | | | | |
| Dredging First Cost | | 25,150,000 | 24,836,250 | 15,171,250 | 65,157,500 |
| Planning/Engineering/Design | | 1,584,450 | 1,564,684 | 955,789 | 4,104,923 |
| Engineering During Construction | | 377,250 | 372,544 | 227,569 | 977,363 |
| Const Mgnt | | 1,447,454 | 1,429,397 | 873,149 | 3,750,000 |
| Project Management | | 377,250 | 372,544 | 227,569 | 977,363 |
| Subtotal (GNF Costs) | | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| Navigational Aids (USCG) | | | | | 27,000 |
| Subtotal | | | | | 74,994,149 |
| | | | | | |
| IDC | | 4,046,473 | 2,334,580 | 463,688 | 6,844,741 |
| Dredging Investment Cost | | | | | 81,838,890 |
| Annualized Investment | | | | | 4,745,069 |
| OMRR&R | | | | | 1,245,246 |
| Dredging Annual Cost | | | | | 5,990,315 |
| | | | | | |
| Total Annual | | | | | 22,162,748 |

**Table 87. Alternative 6, 53 ft Channel-Tunnel (No Fuel)**

| | 2007 ($) | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|---|
| First Cost Tunnel | 2,667,124 | 31,216,385 | 55,423,960 | 26,012,598 | 115,320,066 |
| Mitigation Cost | 116,109 | 66,701 | 64,231 | 1,058,559 | 1,305,600 |
| Bypass Dredging Mitigation | 0 | 0 | 0 | 325,000 | 325,000 |
| Lands and Damages | 13,318 | 0 | 0 | 0 | 13,318 |
| Subtotal | 2,796,551 | 31,283,086 | 55,488,190 | 27,396,157 | 116,963,984 |
| | | | | | |
| Engr Planning Const Mgnt 8.63% | 503,968 | 5,898,516 | 10,472,676 | 4,915,230 | 21,790,390 |
| Indirect 44.14% | 1,194,051 | 13,975,334 | 24,812,879 | 11,645,639 | 51,627,903 |
| Subtotal | 4,494,570 | 51,156,936 | 90,773,745 | 43,957,026 | 190,382,277 |
| | | | | | |
| IDC | 901,209 | 7,153,796 | 7,416,114 | 1,165,884 | 16,637,003 |
| Tunnel Investment Cost | | | | | 207,019,279 |
| Annualized Investment | | | | | 12,003,105 |
| OMRR&R | | | | | 6,885,373 |
| Tunnel Annual Cost | | | | | 18,888,478 |
| | | | | | |
| First Cost Dredging | | 25,150,000 | 24,836,250 | 15,171,250 | 65,157,500 |
| Planning/Engr/Design | | 1,584,450 | 1,564,684 | 955,789 | 4,104,923 |
| Engr During Construction | | 377,250 | 372,544 | 227,569 | 977,363 |
| Constr Mgnt | | 1,447,454 | 1,429,397 | 873,149 | 3,750,000 |
| Project Mgnt | | 377,250 | 372,544 | 227,569 | 977,363 |
| Subtotal (GNF Costs) | | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| | | | | | |
| Navigational Aids (USCG) | | 0 | 0 | 27,000 | 27,000 |
| Subtotal | | 28,936,405 | 28,575,419 | 17,482,325 | 74,994,149 |
| | | | | | |
| IDC | | 4,046,473 | 2,334,580 | 463,688 | 6,844,741 |
| Dredging Investment Cost | | | | | 81,838,890 |
| Annualized Investment | | | | | 4,745,069 |
| OMRR&R | | | | | 1,245,246 |
| Channel Annual Cost | | | | | 5,990,315 |
| | | | | | |
| Total Annual | | | | | 24,878,793 |

### Table 88. Alternative 7, Offshore Fuel Multi-Buoy Mooring

| | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|
| First Cost | 25,719,569 | 25,719,569 | 51,439,137 |
| Storage Tank | 730,557 | 730,557 | 1,461,113 |
| Mitigation Cost | 1,071,979 | 4,448,021 | 5,520,000 |
| Subtotal | 13,318 | 0 | 13,318 |
| Indirect (12.44%) | 3,634,568 | 3,634,568 | 7,269,136 |
| Contingency (33.53%) | 9,796,388 | 9,796,388 | 19,592,775 |
| Subtotal | 40,966,378 | 44,329,102 | 85,295,479 |
| IDC | 3,346,907 | 1,175,752 | 4,522,660 |
| Investment Cost | | | 89,818,139 |
| Annualized Investment | | | 5,207,711 |
| OMRR&R | | | 3,824,314 |
| Total Annual Cost | | | 9,032,025 |

### Table 89. Alternative 8, Offshore Fuel And 3rd Barge

| | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|
| **Offshore Fuel** | | | |
| First Cost | 25,719,569 | 25,719,569 | 51,439,137 |
| Storage Tank | 730,557 | 730,557 | 1,461,113 |
| Mitigation Cost | 1,071,979 | 4,448,021 | 5,520,000 |
| Subtotal | 13,318 | 0 | 13,318 |
| Indirect (12.44%) | 3,425,407 | 3,843,729 | 7,269,136 |
| Contingency (33.53%) | 9,232,627 | 10,360,148 | 19,592,775 |
| Subtotal | 40,193,456 | 45,102,024 | 85,295,479 |
| IDC | 3,283,760 | 1,196,253 | 4,480,013 |
| Investment Cost | | | 89,775,492 |
| Annualized Investment | | | 5,205,238 |
| OMRR&R | | | 3,824,314 |
| Offshore Fuel Annual | | | 9,029,552 |
| **3rd Barge** | | | |
| Investment Cost (IDC included) | | | 24,346,600 |
| Annualized Investment | | | 1,411,631 |
| OMRR&R | | | 2,325,200 |
| 3rd Barge Annual Cost | | | 3,736,831 |
| **Offshore Fuel And 3rd Barge Annual Cost** | | | 12,766,383 |

**Table 90. Alternative 9, Breakwater And Offshore Fuel**

| | 2008 | 2009 | 2010 | Total ($) |
|---|---|---|---|---|
| Breakwater | | | | |
| First Cost | $18,187,783 | $18,187,783 | $18,187,783 | $54,563,348 |
| Mitigation | $39,703 | $1,038,893 | $4,441,404 | $5,520,000 |
| Bypass Dredging Mitigation | $0 | $0 | $325,000 | $325,000 |
| Subtotal | $18,227,486 | $19,226,676 | $22,954,186 | $60,408,348 |
| Planning/Engineering/Design (7.5%) | $1,367,061 | $1,442,001 | $1,721,564 | $4,530,626 |
| Construction Management (11.5%) | $2,096,161 | $2,211,068 | $2,639,731 | $6,946,960 |
| Lands and Damages | $13,318 | $0 | $0 | $13,318 |
| Subtotal (GNF Costs) | $21,704,026 | $22,879,744 | $27,315,482 | $71,899,252 |
| Navigational Aids (USCG) | $0 | $0 | $25,000 | $25,000 |
| Subtotal | $21,704,026 | $22,879,744 | $27,340,482 | $71,924,252 |
| Years of IDC (half years) | 2.50 | 1.50 | 0.50 | |
| Interest During Construction | $3,033,233 | $1,869,250 | $725,159 | $5,627,641 |
| Investment Cost | | | | $77,551,893 |
| Annualized Investment | | | | $4,496,506 |
| OMRR&R | | | | $425,153 |
| | | | | |
| Annual Cost Breakwater | | | | $4,921,659 |
| Offshore Fuel | | | | |
| First Cost Multi-Buoy Mooring (MBM) | $0 | $25,719,569 | $25,719,569 | $51,439,137 |
| Storage Tank | $0 | $730,557 | $730,557 | $1,461,113 |
| Mitigation (cost-included above) | $0 | $0 | $0 | $0 |
| Subtotal (Costs) | $0 | $26,450,125 | $26,450,125 | $52,900,250 |
| Indirect (12.44%) | $0 | $3,290,396 | $3,290,396 | $6,580,791 |
| Contingency (33.53%) | $0 | $8,868,727 | $8,868,727 | $17,737,454 |
| Sub-total | $0 | $38,609,247 | $38,609,247 | $77,218,495 |
| Years of IDC (half years) | 2.5 | 1.5 | 0.5 | |
| Interest During Construction | $0 | $3,154,332 | $1,024,043 | $4,178,375 |
| Investment Cost | | | | $81,396,870 |
| Annualized Investment | | | | $4,719,441 |
| OMRR&R | | | | $3,824,314 |
| Annual Cost Offshore Fuel | | | | $8,543,754 |
| | | | | |
| Total Average Annual Cost-Breakwater & Offshore Fuel | | | | $13,465,414 |

**Table 91. Alternative 10, Breakwater And Offshore Fuel And 3rd Barge**

| Summary Data From Other Tables | Annual Cost ($) |
|---|---|
| Breakwater | 4,921,659 |
| MBM | 8,543,754 |
| Third Barge | 3,736,831 |
| Breakwater & 3rd Barge & Offshore Fuel | 17,202,245 |

**Table 92. Alternative 11, 53 ft Channel And Trestle (With Fuel)**

| | 2007 ($) | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|---|
| First Cost Trestle | 3,022,099 | 35,371,067 | 62,800,500 | 29,474,692 | 130,668,358 |
| Mitigation Cost | 116,109 | 66,701 | 64,231 | 1,058,559 | 1,305,600 |
| Bypass Dredging Mitigation | 0 | 0 | 0 | 325,000 | 325,000 |
| Owner's Costs | 180,753 | 2,115,556 | 3,756,121 | 1,762,892 | 7,815,322 |
| Lands and Damages | 13,318 | 0 | 0 | 0 | 13,318 |
| Planning/Engr/Design | 149,364 | 1,748,179 | 3,103,850 | 1,456,756 | 6,458,149 |
| Const Mgnt | 205,073 | 2,400,205 | 4,261,507 | 2,000,089 | 8,866,875 |
| Subtotal | 3,686,716 | 41,701,708 | 73,986,209 | 36,077,989 | 155,452,622 |
| IDC | 738,745 | 5,831,575 | 6,044,591 | 956,906 | 13,571,816 |
| Investment Cost | | | | | 169,024,438 |
| Annualized Investment | | | | | 9,800,141 |
| OMRR&R | | | | | 6,550,459 |
| Annualized Cost of Trestle | | | | | 16,350,600 |
| | | | | | |
| First Cost Channel | | 25,150,000 | 24,836,250 | 15,171,250 | 65,157,500 |
| Planning/Engr/Design | | 1,584,450 | 1,564,684 | 955,789 | 4,104,923 |
| Engineering During Construction | | 377,250 | 372,544 | 227,569 | 977,363 |
| Constr Mgnt | | 1,447,454 | 1,429,397 | 873,149 | 3,750,000 |
| Project Mgnt | | 377,250 | 372,544 | 227,569 | 977,363 |
| Subtotal (GNF) | | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| Nav Aids (USCG) | | 0 | 0 | 0 | 0 |
| Subtotal | | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| IDC | | 4,046,473 | 2,334,580 | 462,972 | 6,844,025 |
| Investment Cost | | | | | 81,811,174 |
| Annualized Investment | | | | | 4,743,462 |
| OMRR&R | | | | | 1,245,246 |
| Annualized Cost of Channel | | | | | 5,988,708 |
| | | | | | |
| Annual Cost Of Channel And Trestle | | | | | 22,339,308 |

**Table 93. Alternative 12, 53 ft Channel And Tunnel (With Fuel)**

| | 2007 ($) | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|---|
| First Cost Tunnel | 2,843,903 | 33,285,442 | 59,097,521 | 27,736,742 | 122,963,608 |
| Tank | 33,793 | 395,514 | 702,225 | 329,581 | 1,461,113 |
| Mitigation Cost | 116,109 | 66,701 | 64,231 | 1,058,559 | 1,305,600 |
| Bypass Dredging Mitigation | 0 | 0 | 0 | 325,000 | 325,000 |
| Lands and Damages | 13,318 | 0 | 0 | 0 | 13,318 |
| Subtotal | 3,007,123 | 33,747,656 | 59,863,977 | 29,449,882 | 126,068,639 |
| EPCM (18.63%) | 560,227 | 6,287,188 | 11,152,659 | 5,486,513 | 23,486,587 |
| Indirect (44.14%) | 1,327,344 | 14,896,216 | 26,423,960 | 12,999,178 | 55,646,697 |
| Subtotal | 4,894,694 | 54,931,060 | 97,440,596 | 47,935,573 | 205,201,924 |
| IDC | 981,677 | 7,681,570 | 7,960,788 | 1,271,408 | 17,895,443 |
| Investment Cost | | | | | 223,097,367 |
| Annualized Investment | | | | | 12,935,322 |
| OMRR&R | | | | | 6,885,373 |
| Annual Cost of Tunnel | | | | | 19,820,695 |
| | | | | | |
| First Cost Channel | | 25,150,000 | 24,836,250 | 15,171,250 | 65,157,500 |
| Planning/EngrDesign | | 1,584,450 | 1,564,684 | 955,789 | 4,104,923 |
| Engr During Const | | 377,250 | 372,544 | 227,569 | 977,363 |
| Const Management | | 1,447,454 | 1,429,397 | 873,149 | 3,750,000 |
| Project Management | | 377,250 | 372,544 | 227,569 | 977,363 |
| Subtotal (GNF Costs) | | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| Nav Aids (USCG) | | 0 | 0 | 27,000 | 27,000 |
| Subtotal | | 28,936,405 | 28,575,419 | 17,482,325 | 74,994,149 |
| IDC | | 4,046,473 | 2,334,580 | 463,688 | 6,844,741 |
| Investment Cost | | | | | 81,838,890 |
| Annualized Investment | | | | | 4,745,069 |
| OMRR&R | | | | | 1,245,246 |
| Annual Cost of Dredging | | | | | 5,990,315 |
| | | | | | |
| Annual Cost Of Channel And Tunnel (With Fuel) | | | | | 25,811,010 |

**Table 94. Trestle Length Variation, 1,450 ft Trestle**

| | 2007 ($) | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|---|
| First Cost Trestle | 3,022,099 | 35,371,067 | 62,800,500 | 29,474,692 | 130,668,358 |
| Mitigation Cost | 116,109 | 66,701 | 64,231 | 1,058,559 | 1,305,600 |
| Bypass Dredging Mitigation | 0 | 0 | 0 | 325,000 | 325,000 |
| Owner's Costs | 180,753 | 2,115,556 | 3,756,121 | 1,762,892 | 7,815,322 |
| Lands and Damages | 13,318 | 0 | 0 | 0 | 13,318 |
| Planning/Engr/Design | 149,364 | 1,748,179 | 3,103,850 | 1,456,756 | 6,458,149 |
| Const Mgnt | 205,073 | 2,400,205 | 4,261,507 | 2,000,089 | 8,866,875 |
| Subtotal | 3,686,716 | 41,701,708 | 73,986,209 | 36,077,989 | 155,452,622 |
| IDC | 738,745 | 5,831,575 | 6,044,591 | 956,906 | 13,571,816 |
| Total Investment Cost | | | | | 169,024,438 |
| Annualized Investment | | | | | 9,800,141 |
| OMRR&R | | | | | 6,550,459 |
| | | | | | |
| Annual Cost | | | | | 16,350,600 |

**Table 95. Trestle Length Variation, 2,000 ft Trestle**

| | 2007 ($) | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|---|
| First Cost Trestle | 3,058,329 | 37,303,857 | 66,834,784 | 31,565,875 | 138,762,845 |
| Mitigation Cost | 116,109 | 66,701 | 64,231 | 1,058,559 | 1,305,600 |
| Bypass Dredging Mitigation | 0 | 0 | 0 | 325,000 | 325,000 |
| Owner's Costs | 172,249 | 2,101,007 | 3,764,231 | 1,777,835 | 7,815,322 |
| Lands and Damages | 13,318 | 0 | 0 | 0 | 13,318 |
| Planning/Engr/Design | 183,374 | 2,236,700 | 4,007,343 | 1,892,656 | 8,320,073 |
| Const Management | 254,927 | 3,109,461 | 5,571,011 | 2,631,172 | 11,566,571 |
| Subtotal | 3,798,307 | 44,817,726 | 80,241,599 | 39,251,098 | 168,108,729 |
| IDC | 761,186 | 6,267,320 | 6,555,649 | 1,041,067 | 14,625,222 |
| Total Investment Cost | | | | | 182,733,951 |
| Annualized Investment | | | | | 10,595,027 |
| OMRR&R | | | | | 6,652,954 |
| Annual Cost | | | | | 17,247,981 |

**Table 96. Trestle Length Variation, 2,600 ft Trestle**

| | 2007 ($) | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|---|
| First Cost Trestle | 3,086,317 | 41,188,906 | 72,738,187 | 33,931,691 | 150,945,101 |
| Mitigation Cost | 116,109 | 66,701 | 64,231 | 1,058,559 | 1,305,600 |
| Bypass Dredging Mitigation | 0 | 0 | 0 | 325,000 | 325,000 |
| Owner's Costs | 159,797 | 2,132,594 | 3,766,087 | 1,756,845 | 7,815,322 |
| Lands and Damages | 13,318 | 0 | 0 | 0 | 13,318 |
| Planning/Engr/Design | 191,527 | 2,556,050 | 4,513,896 | 2,105,691 | 9,367,164 |
| Const Mgnt | 249,071 | 3,324,010 | 5,870,087 | 2,738,341 | 12,181,509 |
| Subtotal | 3,816,139 | 49,268,261 | 86,952,488 | 41,916,127 | 181,953,014 |
| IDC | 764,772 | 6,889,683 | 7,103,921 | 1,111,752 | 15,870,129 |
| Total Investment Cost | | | | | 197,823,143 |
| Annualized Cost | | | | | 11,469,907 |
| OMRR&R | | | | | 6,751,659 |
| Annual Cost | | | | | 18,221,566 |

**Table 97. Channel Depth Variation, 53 ft Channel, –20 ft Contour**

| | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost | 25,150,000 | 24,836,250 | 15,171,250 | 65,157,500 |
| Planning/Engr/Design | 1,584,450 | 1,564,684 | 955,789 | 4,104,923 |
| Engineering During Const | 377,250 | 372,544 | 227,569 | 977,363 |
| Const Mgnt | 1,447,454 | 1,429,397 | 873,149 | 3,750,000 |
| Project Mgnt | 377,250 | 372,544 | 227,569 | 977,363 |
| Subtotal | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| Nav Aids (USCG) | 0 | 0 | 0 | 0 |
| Subtotal | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| IDC | 4,046,473 | 2,334,580 | 462,972 | 6,844,025 |
| Total Investment Cost | | | | 81,811,174 |
| Annualized Investment | | | | 4,743,462 |
| OMRR&R | | | | 1,245,246 |
| Annual Cost | | | | 5,988,708 |

**Table 98. Channel Depth Variation, 50 ft Channel, –20 ft Contour**

| | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost | 25,150,000 | 24,836,250 | 2,871,250 | 52,857,500 |
| Planning/Engr/Design | 1,953,154 | 1,928,788 | 222,982 | 4,104,923 |
| Engr During Construction | 465,037 | 459,235 | 53,091 | 977,363 |
| Const Mgnt | 1,784,278 | 1,762,019 | 203,702 | 3,750,000 |
| Project Management | 465,037 | 459,235 | 53,091 | 977,363 |
| Subtotal | 29,817,506 | 29,445,528 | 3,404,116 | 62,667,149 |
| Nav Aids (USCG) | 0 | 0 | 0 | 0 |
| Subtotal | 29,817,506 | 29,445,528 | 3,404,116 | 62,667,149 |
| IDC | 4,169,686 | 2,405,667 | 90,288 | 6,665,641 |
| Total Investment Cost | | | | 69,332,790 |
| Annualized Investment | | | | 4,019,958 |
| OMRR&R | | | | 1,065,966 |
| Annual Cost | | | | 5,085,924 |

## Table 99. Channel Depth Variation, 47 ft Channel, –20 ft Contour

| | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost | 25,150,000 | 17,461,250 | 0 | 42,611,250 |
| Planning/Engr/Design | 2,422,806 | 1,682,117 | 0 | 4,104,923 |
| Engr During Construction | 576,859 | 400,504 | 0 | 977,363 |
| Constr Mgnt | 1,475,549 | 1,024,451 | 0 | 2,500,000 |
| Project Management | 576,859 | 400,504 | 0 | 977,363 |
| Subtotal | 30,202,074 | 20,968,825 | 0 | 51,170,899 |
| Nav Aids (USCG) | 0 | 0 | 0 | 0 |
| Subtotal | 30,202,074 | 20,968,825 | 0 | 51,170,899 |
| | | | | |
| IDC | 4,223,464 | 1,713,130 | 0 | 5,936,594 |
| Total Investment Cost | | | | 57,107,493 |
| Annualized Investment | | | | 3,311,128 |
| OMRR&R | | | | 953,500 |
| | | | | |
| Annual Cost | | | | 4,264,628 |

## Table 100. 53 ft Channel Length Variation (With 2,600 ft Trestle)

| | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost | 25,150,000 | 24,836,250 | 5,982,500 | 55,968,750 |
| Planning/Engr/Design | 1,844,580 | 1,821,568 | 438,775 | 4,104,923 |
| Engineering During Const | 439,186 | 433,707 | 104,470 | 977,363 |
| Const Mgnt | 1,685,092 | 1,664,070 | 400,838 | 3,750,000 |
| Project Mgnt | 439,186 | 433,707 | 104,470 | 977,363 |
| Subtotal | 29,558,043 | 29,189,302 | 7,031,053 | 65,778,399 |
| Nav Aids (USCG) | 0 | 0 | 0 | 0 |
| Subtotal | 29,558,043 | 29,189,302 | 7,031,053 | 65,778,399 |
| | | | | |
| IDC | 4,133,403 | 2,384,733 | 186,486 | 6,704,622 |
| Total Investment Cost | | | | 72,483,021 |
| Annualized Investment | | | | 4,202,610 |
| OMRR&R | | | | 1,013,804 |
| | | | | |
| Annual Cost | | | | 5,216,414 |

**Table 101. 53 ft Channel Length Variation (With 2,000 ft Trestle)**

| | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost | 25,150,000 | 24,836,250 | 11,302,500 | 61,288,750 |
| Planning/Engr/Design | 1,684,466 | 1,663,452 | 757,005 | 4,104,923 |
| Engr During Construction | 401,063 | 396,060 | 180,239 | 977,363 |
| Const Mgnt | 1,538,822 | 1,519,625 | 691,552 | 3,750,000 |
| Project Management | 401,063 | 396,060 | 180,239 | 977,363 |
| Subtotal | 29,175,415 | 28,811,448 | 13,111,536 | 71,098,399 |
| Nav Aids (USCG) | 0 | 0 | 0 | 0 |
| Subtotal | 29,175,415 | 28,811,448 | 13,111,536 | 71,098,399 |
| IDC | 4,079,896 | 2,353,863 | 347,761 | 6,781,520 |
| Total Investment Cost | | | | 77,879,919 |
| Annualized Investment | | | | 4,515,526 |
| OMRR&R | | | | 1,084,362 |
| Annual Cost | | | | 5,599,888 |

**Table 102. 53 ft Channel Length Variation (With 1,450 ft Trestle)**

| | 2008 ($) | 2009 ($) | 2010 ($) | Total ($) |
|---|---|---|---|---|
| First Cost | 25,150,000 | 24,836,250 | 15,171,250 | 65,157,500 |
| Planning/Engr/Design | 1,584,450 | 1,564,684 | 955,789 | 4,104,923 |
| Engr During Construction | 377,250 | 372,544 | 227,569 | 977,363 |
| Constr Mgnt | 1,447,454 | 1,429,397 | 873,149 | 3,750,000 |
| Project Management | 377,250 | 372,544 | 227,569 | 977,363 |
| Subtotal | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| Nav Aids (USCG) | 0 | 0 | 0 | 0 |
| Subtotal | 28,936,405 | 28,575,419 | 17,455,325 | 74,967,149 |
| IDC | 4,046,473 | 2,334,580 | 462,972 | 6,844,025 |
| Total Investment Cost | | | | 81,811,174 |
| Annualized Investment | | | | 4,743,462 |
| OMRR&R | | | | 1,245,246 |
| Annual Cost | | | | 5,988,708 |

**NED plan**. The NED plan is the alternative reasonably demonstrating maximum net benefits with a benefit-to-cost ratio over 1:1. Of the plans that were advanced to the short list of 12 alternatives, several demonstrated benefit-to-cost ratios over 1. Plans, which included a third barge or which excluded fuel supply features, did not fare as well as the plans that included combinations of channel/trestle/fuel or a breakwater with fuel supply.

For purposes of plan comparison, all of the costs and benefits have been converted to annualized amounts using a 5 3/8% interest rate and 50-year project life beginning in 2011. The price level for all benefits and costs is 2004. There are five major NED plan identification issues:

- Identification of the best screened plans in terms of maximum net benefits.
- Determination of the optimum depth for the navigation features.
- Determination of the optimum mix of trestle and channel.

- Incremental justification of the turning basin.
- Justification of required overdepth dredging for efficient maintenance.

**Net Benefit Comparison.** A comparison of annualized cost with annualized benefits is the screening tool that identifies the plan with the maximum net benefits. The plans, which include a combination of trestle and channel and those which include a combination of breakwater and pipeline or pipeline by itself, all demonstrate benefit-to-cost ratios higher than any of the other alternatives. In terms of net benefits, the C-T (channel-trestle) plan variations win out. Relative attractiveness of the C-T plan variations differ only in the depth of channel provided and the length of the trestle needed to serve it. Selection of the NED plan is, therefore, narrowed to the C-T combinations (variations of alternative 11). The focus becomes selection of the best project depth and the trestle/channel length combination which provides maximum net benefits. The following table of benefits and costs indicates the C-T plans are the best choices, and the plan with a channel depth of 53 ft is the best among all plans investigated. It has annual cost of $22,339,308, annual benefits of $26,898,700 and provides a benefit-to-cost ratio of 1.20 with net annual benefits of $4,559,392.

**Table 103. Economic Comparison Of Alternative Plans Nominal 2004 Price Level ($Thousands)**

| Alternative | Total Annual Benefit ($) | Total Annual Cost ($) | B:C | Net Benefits ($) | Order |
|---|---|---|---|---|---|
| Alt 2-3rd Barge | 2,553.5 | 3,736.8 | .68 | (1,183.3) | 9 |
| Alt 3-BW | 4,562.4 | 4,781.6 | .95 | (219.2) | 8 |
| Alt 4-3rd B & BW | 4,757.7 | 8,518.5 | .56 | (3,760.8) | 11 |
| Alt 5-CH+TRS (w/o F) | 15,936.9 | 22,162.7 | .72 | (6,225.8) | 12 |
| Alt 6-CH+TUN (w/o F) | 15,936.9 | 24,878.8 | .64 | (8,941.9) | 13 |
| Alt 7-OF | 11,002.4 | 9,032.0 | 1.22 | 1,970.4 | 5 |
| Alt 8-OF+3B | 13,556.2 | 12,766.4 | 1.06 | 789.8 | 7 |
| Alt 9-OF+BW | 15,564.8 | 13,465.4 | 1.16 | 2,099.4 | 4 |
| Alt 10-OF+3B+BW | 15,760.1 | 17,202.2 | .92 | (1,442.1) | 10 |
| Alt 11-CH+TRS (w/F) | | | | | |
| T-C 47 ft | 24,780.8 | 20,615.2 | 1.20 | 4,165.6 | 3 |
| T-C 50 ft | 25,898.9 | 21,436.5 | 1.21 | 4,462.4 | 2 |
| T-C 53 ft | 26,898.7 | 22,339.3 | 1.20 | 4,559.4 | 1 |
| Alt 12-CH+TUN (w/F) | 26,898.7 | 25,811.0 | 1.04 | 1,087.7 | 6 |

**Optimum Depth for the Navigation Features.** Given that all scales of the C-T plans are justified and that they are better than any other alternative, there is still the issue of the best depth. To determine this, a benefit curve for six depths (41 ft, 44 ft, 47 ft, 50 ft, 53 ft and 56 ft) was compared against a cost curve based on depths of 47 ft, 50 ft, and 53 ft. Early on it was abundantly clear that the NED plan would most likely be in the 47 ft–53 ft range. Since the other depths offered less promise for obvious reasons, they are given a lower profile in this report. Nevertheless the accuracy, precision, and certainty surrounding the benefit analysis is similar for all of the project depths investigated.

Each of the depths includes a design allowance for 8 ft under keel clearance, and the cost estimates include an allowance for initial required overdepth dredging for efficient maintenance of the design depth. Identification and justification of the 8 ft under keel clearance was on grounds of conventional engineering practice and represents a significant project cost increment. Justification of the 8 ft under keel clearance is in the hydraulic design appendix.

After adjusting for the under keel clearance, the six channel depths are capable of accommodating maximum vessel drafts of 34 ft, 37 ft, 39 ft, 42 ft, 45 ft, and 48 ft respectively. The deepest vessel in the fleet, regularly serving Portsite, drafts 45 ft so the 53 ft deep channel will allow unfettered use of the without-project condition fleet. Vessels with a draft in excess of 45 ft are not a practical choice due to destination port restraints and buying habits of destination smelters thus indicating channel depths beyond 53 ft provide zero incremental value added.

The channel needs to be deep enough to accommodate Panamax carriers, because they make up a notable portion of the fleet. At depths less than 53 ft, there is some substituting of smaller vessels or light loaded vessels for the fully loaded Panamax, hence more vessel trips are needed thus eroding the benefits achieved at 53 ft. For channels shallower than 53 ft, the effect of fleet adjustments is to save less in terms of overall transportation costs.

The following chart demonstrates the maximization of project depth at 53 ft in the sense that it provided the maximum net benefits among the six depths evaluated. The 53 ft depth is tentatively selected as the NED depth on the grounds that a deeper channel will present greater construction cost plus greater O&M costs while not earning adequate incremental benefits to cover the added cost. Using the "most likely" parameters, there is $97,200 difference in annual net benefits between the 50 ft and 53 ft channel.

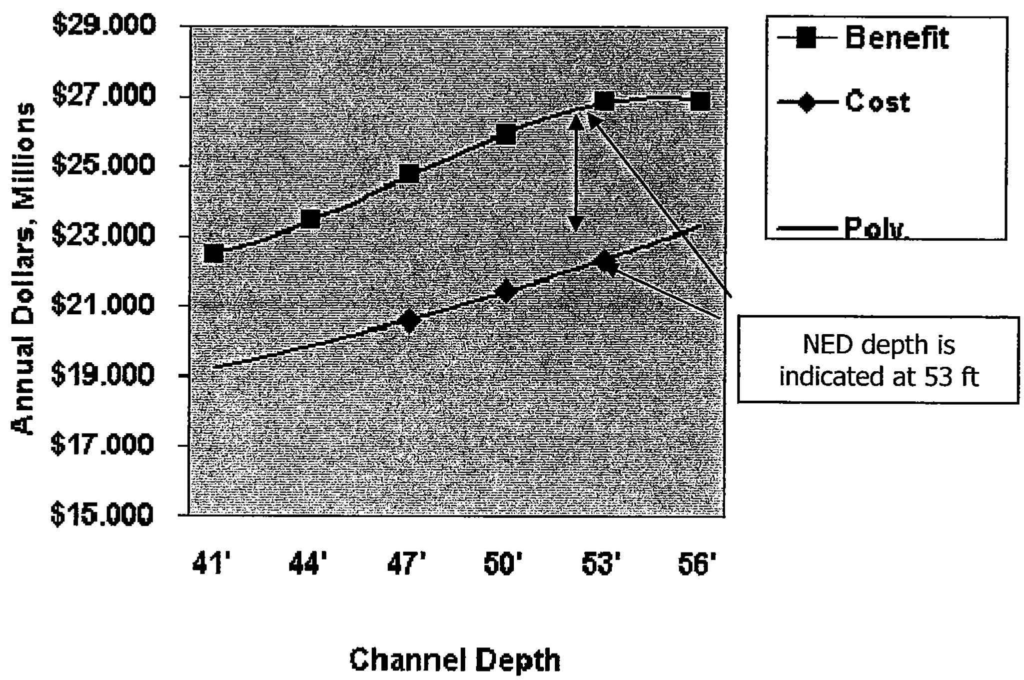


Figure 8. Display Of The NED Scale (Maximum Difference @ 53 ft Indicates The NED plan)

The above figure, generated by "most likely" parameters, displays the similarity of net benefits for the 50 ft and 53 ft depths. See table 106 for a specific comparison of cost benefits and net benefits for incremental depths. As further explained in section 17 of this appendix, the NED plan decision favoring 53 ft is enhanced under "high range" parameters.

**Optimum Mix of Trestle and Channel.** There are countless combinations of trestle and channel configurations (length combinations) that can provide a 53 ft project just as there are combinations that can provide projects at other depths. Identification of the best mix of trestle and channel is done using cost-effectiveness techniques with a 53 ft channel depth being the objective function.

In figure 11 the optimum mix favors a trestle of 1,450 ft in length, because it is known that, at lengths of less than 1,450 ft, the cost of the channel part of the project suddenly begins to increase rapidly for two reasons. First, inside of the –20 ft contour, the dredging could encounter harder material and this would demand a different set of procedures and equipment, both adding cost, time, and technical issues to the activity. Second, as the channel gets within 1,450 ft of shore, dredging maintenance presents an extraordinary challenge. This is due to the fact that, in the near shore environment at depths of 15 ft, bottom sediment transport associated with littoral drift can become quite severe with relatively minor storms.

After consideration of the hard material and potential maintenance issues, the channel has been limited to beyond the –20 ft contour to prevent intrusion into the active littoral drift zone. This happens to correspond to a trestle length of 1,450 ft. Within the active littoral drift zone, there are serious limitations that dredging activity would present to the serviceability of the project even knowing that with appropriate equipment on the scene channel work could be conducted as weather and wave conditions permit.

Both the hard material and the added dredging activity would drive the cost curve upward for plans with a trestle length under 1,450 ft. In addition to these significant cost factors, there is the consequential adverse impact on project use that is probably the major economic cost driving the decision to not extend the channel inside of 1,450 ft. When dredging takes place during the shipping season, the dredge will occupy the channel in an attempt to make it useable in the shortest possible time. There could be pressure to have the dredge vacate the channel in favor of allowing the project to be used by some of the smaller deep draft carriers that might be able to navigate the degraded channel even though the working dredge has a right of way. Since the dredge is unlikely to vacate, all shipping would be interrupted. As this interruption of shipping happens, then each day that the dredge has to occupy the channel will have a dependent economic cost which could range from zero, if there are no vessels using the channel or waiting to use the channel, to as high as $2,290,000, if the active shipping season needed to maintain target throughput is shortened by one day (yearly net cash flow $251,900,000/110 day season = $2,290,000 per day). Furthermore, if dredging causes a ship to be diverted, then losses run into the tens of millions, because this will cut heavily into the total quantity that can be shipped for the year. There is some consolation that the missed shipments can be made up in the last year of the mine life, but the present worth of that mitigation is very small.

In any year, a most likely case would be infill of the channel, shortening the shipping season of the current or following year by an average of 30 days. Near the end of the season, ships queue up waiting to load, and there can be two to four present. As an example of a minor disruption, holding up four of them for just a week would accrue a loss of $315,840 in weighted average cost of delay time alone without considering the cost of dredging or the economic consequences of a missed shipment. Given any scenario, the loss potential is very high. If an interruption steals needed loading days from the season and one ship cannot be loaded, the loss is roughly $10 million per ship turned away. When this range of potential losses is weighed against the daily cost of a dredge, it becomes obvious that the dredge needs to occupy the channel on a priority basis to clear it at the earliest possible time. The potential shipping closure is an adverse economic impact and is treated as an economic cost of extending the channel closer to shore than the –20 ft contour.

The annual cost for a channel reaching closer to shore than the end of the 1,450 ft trestle was estimated by using the net increment of channel and trestle cost for the next size up and adding it to the cost of the 53 ft/1,450 ft plan. This does not account for greater quantities to be dredged in the near shore shallower area or the definite possibility of rock being encountered and is somewhat of an underestimate. However, since it was shown to have associated adverse economic effects, making it too costly to compete with other lengths of channel, the fact that it is a low estimate is inconsequential. To this number was added the economic cost of benefits lost, based on the average net cash flow forgone when a needed loading day is lost from the season, $2,290,000.

A 30-day dredging work period would be accompanied by an assumed three weeks needed for planning, preparation, and mobilization. An interruption of shipping could span more or less than 51 days; however, a 51-day loss would result in a loss of all of the season gap days and three necessary loading days equivalent to $6,870,000. It is possible that this extended period could result in a ship being rerouted, and this would add about $10 million in economic cost. The above does not include ship delay cost.

Regardless of how much shorter the channel length is that this related economic cost is associated with, it turns out that the least cost channel-trestle combination is the 1,450 ft channel. This is because, with these considerations, a length of channel is more costly inside of the –20 ft contour than an equivalent length of trestle. The cost of the channel per unit of length is fairly constant up to the –20 ft contour where these other factors come into play. The following figure 11 illustrates how considerations of changed conditions inside the –20 contour bear on identification of the optimum mix.

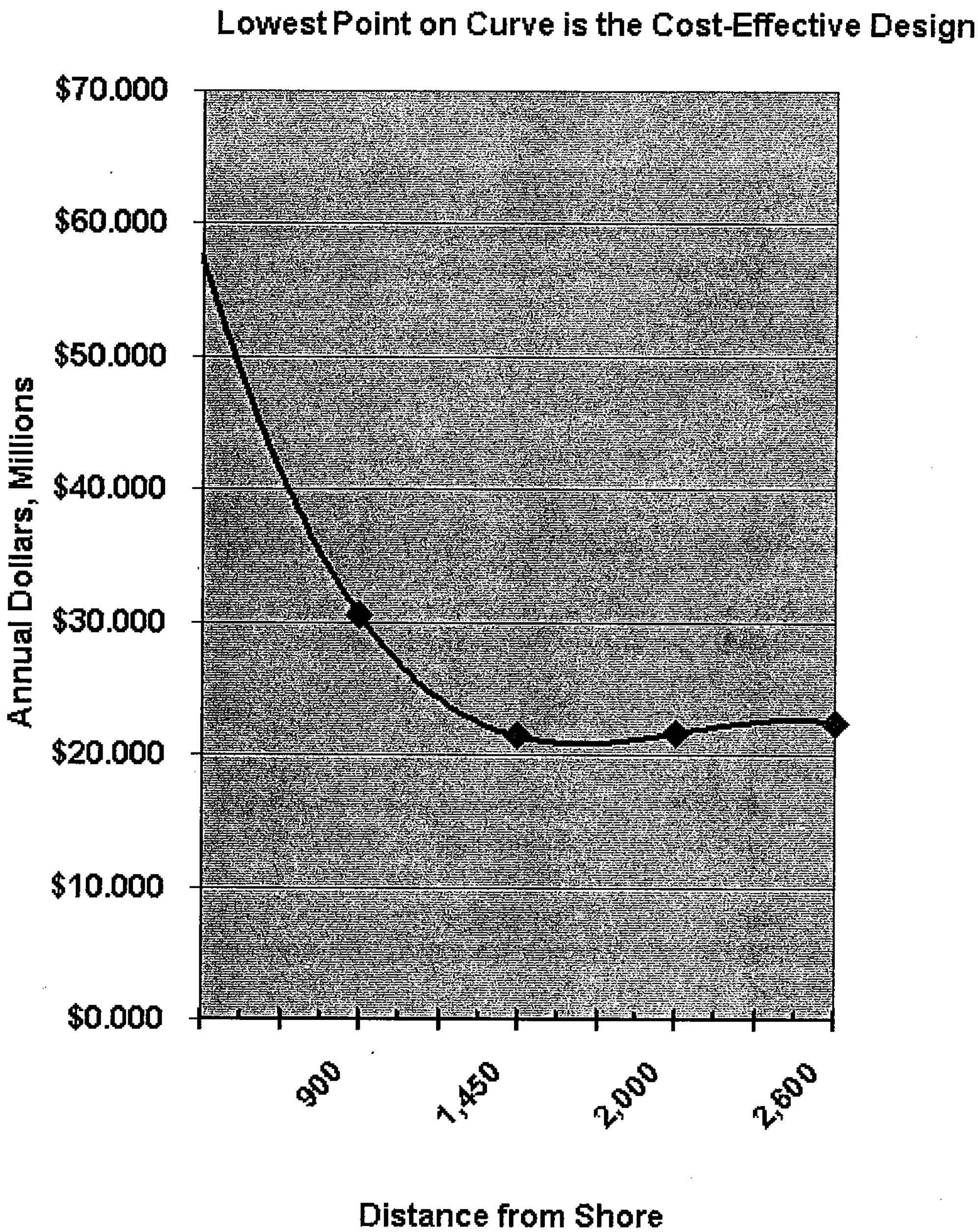


Figure 9. Least Cost Channel-Trestle Length Combination, 53 ft Channel

The following table demonstrates a 1,450 ft trestle in combination with a 53 ft channel is the best choice among alternatives depicted in the table. Viewing figure 11 may help the economic argument in support of not extending dredging inside of the –20 ft contour.

**Table 104. Optimization Of Channel Depth And Channel Length, Alternative 11**

| | Annualized Cost And Annualized Benefits | | |
|---|---|---|---|
| | 1,450 ft Trestle –20 ft Contour End | 2,000 ft Trestle –24 ft Contour End | 2,600 ft Trestle –28 ft Contour End |
| **53 ft DEPTH** | | | |
| Benefit | $26,898,700 | $26,898,700 | $26,898,700 |
| Cost | $22,339,308 | $22,847,868 | $23,437,981 |
| Net Benefit | $4,559,392 | $4,050,832 | $3,460,719 |
| **50 ft DEPTH** | | | |
| Benefit | $25,898,900 | $25,898,900 | $25,898,900 |
| Cost | $21,436,524 | $21,646,717 | $22,462,468 |
| Net Benefit | $4,462,376 | $4,252,183 | $3,436,432 |
| **47 ft DEPTH** | | | |
| Benefit | $24,780,800 | $24,780,800 | $24,780,800 |
| Cost | $20,615,227 | $21,149,206 | $22,039,519 |
| Net Benefit | $4,165,573 | $3,631,594 | $2,741,281 |

**Incremental Justification of the Turning Basin.** A turning basin is provided to allow vessels to arrive at the dock bow first and then turn their stern to shore as preparation for a safe departure under their own power in the event a weather evacuation of the loading dock is required. Partially loaded vessels will return to the dock for topping off and will need to be turned as well.

Without a turning basin, vessels will need to be situated at the dock by tugs either moving them into place stern first or by extracting them stern first. This is not an impossible task but with a cross-current and a persistent wind, a nearly loaded vessel, nosed into the dock and not able to power itself out, could have a difficult time staying in the channel. The risk of grounding outside of the channel has not been quantified under these conditions, but one incident could have monumental economic consequences, stemming from a consequential shut down of the loading operation as well as catastrophic vessel damages. There would be a high risk with only two tractor tugs assisting; therefore, a third tractor tug is assumed to be necessary to compensate for the fact that the deep draft vessel will not have close quarter self operated directional control when underway stern first.

The addition of a turning basin allows vessels to leave on short notice under their own power, thus increasing the margin of safety and saving the cost of an additional tug. Availability of the basin enables vessels to escape being caught at the dock in a storm, thus avoiding damage to themselves and the dock, even if the tugs are not immediately available to them. It also allows vessels to be docked under safer circumstances, and it avoids the delay associated with a long tug-dependent approach or delay associated with a tug assisted extraction stern first.

There is no accurate measure of the added time a stern first docking or extraction will take. The model simulations, explained in the report, do not explore stern first docking and extraction extensively enough to allow development of data that could represent relevant conditions and circumstances. The simulations were of tug assisted bow first approaches and departures. However, it is estimated that for the more than 26 vessel calls per year, without a tuning basin, there will be an added 4 hours per vessel or a total of 104 hours. This equates to an additional $1,759,000 cost per year made up of weighted average vessel delay time of $50,600 plus the annual cost of an added 4,000 HP tug at $1,708,400. It is concluded that the turning basin is a wise addition to the project, and at an incremental annual cost of $534,000,[142] is justified on its own merits with a separable B:C of 3.29:1.

Regardless of vessel draft, it is suspected that a bulk carrier being turned might not squat to the degree of a vessel under way in a confined channel, because squat estimates are generally proportional to the square of the vessel speed. Squat makes up less than 2 ft of the allowance for the 8 ft under keel clearance, allowed for in the design of the channel; however, there can be a wide variation in estimated squat, depending on variables such as ship and channel geometry, ship position and speed, and which of several empirical formulas are applied. It would be reasonable to minimize the allowance for squat in that part of the project, provided for the sole purpose of turning a vessel, although there is the prospect that a vessel out of track could overlap the turning basin as happened during ship simulations studies at WES. Nevertheless, the squat allowance has been adjusted to .5 ft for the turning basin.

A positive squat allowance is further supported by the fact that there will be times when partly loaded ships must be topped off after being interrupted by weather. All of these vessels will be out of trim, because trim loading happens at the end of the topping off. For example, a 45 ft draft vessel, returned to the dock for its final foot of load, could easily be out of trim by 1 ft–3 ft and draw more than 45 ft, although it will still draft 45 ft when fully loaded.

Allowing for the turning of these nearly fully loaded vessels saves the cost of bringing in an additional vessel at the end of the season to load the concentrate which would otherwise be left behind. The trip cost of an additional vessel is $401,300. The last 3 ft increment of turning basin has an indicated annual cost of $86,200. This last 3 ft increment of turning basin depth provides an incremental B:C of 4.65:1.

**Justification of Required Overdepth Dredging for Efficient Maintenance (RODFEM).** RODFEM has been proposed to provide assurance that the project depth will be reliable maintained. The RODFEM strategy is to deepen the project beyond the NED depth to provide a sump for deposition of infill material. Justification of the RODFEM is based on it providing the least cost O&M program for the channel, when all costs are reduced to equivalent annual values. RODFEM allows the project to be in use for a longer period of time before dredge equipment and crews need to be mobilized to the site. All details regarding determination of the least cost maintenance plan are treated as technical engineering and are confined to the Hydraulic Design Appendix. The analysis determined the optimal RODFEM was achieved with a sump spread along the entire channel length providing 1.9 million $yd^3$ of capacity.

[142] Estimated cost is annual dredging cost prorated based on quantities for the channel and turning basin shown in the Hydraulic Design Appendix. The turning basin quantities are about 10.5% of the overall channel excavation for the 50' project It should be considered an approximation developed for purposes of this display.

**NED plan Summary.** The NED plan is Alternative 11, a channel-trestle combination with a 53 ft access channel. It has benefits and costs as follows:

| | Benefits | Cost |
|---|---|---|
| Tug and Barge Cost | | $10,788,300 |
| Port and Queue | $3,333,200 | |
| Induced Tons | $1,707,900 | |
| Fuel | $11,002,400 | |
| Costs | | |
| Avoided Cost | $66,900 | |
| Total Annual Benefits | $26,898,7000 | |
| Total Annual Costs | $22,339,300 | |
| Annual Net Benefits | $4,559,400 | |
| Benefit-to-cost ratio | 1.20 : 1 | |

# 17.0 SENSITIVITY OF THE ECONOMICS TO CHANGES IN DATA AND METHODS

**Purpose**. The purpose of this section is to test the sensitivity of the results of the economic analysis to changes in some of the input variables and methods representing the "most likely" case. The value of this test is to reveal how the economic analysis result might vary if inputs selected for the benefit evaluation are selected differently or applied differently thereby providing insight to the amount of confidence one can have in the economic analysis.

Specifically, there are two overarching concerns:

- Does the economic justification stand when the analysis incorporates different data, assumptions, and methods?
- Does identification of the NED plan withstand changes in data, assumptions, and methods?

The first concern is essentially resolved by addressing the range of possibilities of the benefit-to-cost ratio. The second begs a comparison of the possible range of net benefits of the NED plan (plan with maximum net benefits) with the plan closest to it in terms of net benefits. The closest plan to the designated NED plan (Alternative 11 with a 53 ft channel) is Alternative 11 with a 50 ft channel respectively. Therefore many of the displays in this section include both plans.

Issues that deal with variations in data and methods are sometimes referred to as risk and uncertainty (RU) issues, and one of the techniques of revealing their significance is referred to as Sensitivity Analysis. Within other parts of this report, presentation of the probabilistic aspects of the methodology and data provide helpful insight to the risk aspects of the analysis. For example, frequency aspects of wave data can be found in the Hydraulic Design Appendix, and mechanics of weather interruptions to barge transfer and ship loading are illustrated in a stand-alone discussion of the simulator in appendix F. Numerous sources outside of the Economic Analysis Appendix provided inputs for the construction of a probabilistic economic analysis.

Typical of this type of analysis, data is often derived and applied using techniques which themselves are not perfect. Methodology is sometimes selected from more than one available choice and selection may be influenced by time and dollar budgets or by the anticipated significance of a variable in the overall study. Even in cases where data is based on a 100% sample, the results can be distorted by data sources being out of date or by being inappropriately applied or misinterpreted. There is rarely if ever, such a thing as perfectly certain, zero risk, or strictly up to date information. To be perfectly certain, one would need perfect hindsight and foresight, neither one of which exists. To remove all risk, one would need to have a perfect view of the future; to be up to date on all facts, one would have zero time to gather them, analyze them, report them, publish them, and use them.

Taken to an extreme, one would need to examine and test the risk and uncertainty of every concept, assumption, bit of data, analysis, and conclusion, separately and in combination with one another to satisfy all of the possible curiosities. This would be impractical so the scope and intent in this RU discussion is oriented toward identification of the degree to which changes in some of the major aspects of the analysis will have a material affect on the outcome. Since not everything is to be tested, it is necessary to apply some practical judgment to selection of the important variables to be evaluated.

**Selection of Variable.** During the course of preparing the Economic Analysis Appendix, there were numerous decisions made regarding the proper representative data point or mark, among many ranges under consideration. Selection of the appropriate mark was based on rational analysis specifically designed to steer judgment to a "most likely" value. The term "most likely" itself has uncertainty aspects in that it requires some interpretation and judgment, because most likely it is not necessarily something arrived at with a mathematical formula except where statistical outcomes are being compared probabilistically. The activities involved in development of each of the variables, being assessed in this part of the report, contain intermediate judgments and related analysis in combination with significant data and policy inputs. They should not be interpreted as being intended to constitute statistical or mathematical criteria for meeting the criteria for "most likely."

During the course of developing the benefit evaluation and plan formulation, the proposition developed that the outcome for the economics of the NED plan and designation of the NED plan might be more sensitive to changes in some parts of the analysis than others. The proposition stated that some factors more than others can be viewed as determinants of the project's benefits. The factors described as having this characteristic include but are not necessarily limited to the following:

- Volume of concentrate shipped
- Maintenance dredging cycle
- Dedicated fleet tug and barge cost
- Reduction of risk in the concentrate loading operation
- First cost of the trestle
- Fuel savings per gallon
- Number of gallons of fuel used by the mine and villages
- Transportation cost savings of moving fuel from Portsite to the villages
- Ship arrival schedule
- Tractor tug vs. line-haul tug
- Simulation model calibration (wave-weather interpretation)
- Deep draft vessel cost (capital cost)
- Duration of vessel transits

Each of these variables has some significant demonstrable basis for being represented by a potential range of values, and range data for several was identified during the study. This discussion looks at the range values and compares the economic analysis results using the most likely number, with economic analysis results which are produced using the low value and the high value of the range.

**Volume of Concentrate.** A mine cost model was used which allowed mine production economics to be simulated using various inputs for numerous cost components and different assumptions regarding basic site conditions relating to ore quality, content, and overburden. The model has a focus of onsite cash operating costs, using offsite shipment, treatment, and refining charges in order to link the cost of production to refined metal. The profitability (cash flow measure) of the mine was tested by varying the inputs and examining the economics at various output levels thus evaluating earning potential over a range of concentrate production volumes and as a result providing insight into the viability of future commodity shipments.

The World Mine Cost Data Exchange mine cost model used in this report is based on U.S. Bureau of Mines Cost Estimating System or CES, but also uses estimates of specific consumption of supplies such as fuel, power, explosives, grinding media and reagents, and labor requirements, plus adjustment factors for materials consumption and labor productivity. This allows combining the features of statistically-derived models such as CES with the Bill of Goods approach which specifies actual costs and usage of production inputs. The end result is a more accurate production cost estimate that can be verified against known or assumed usage rates of consumables and labor.

Because of the many variables involved in the mining industry, production of concentrate volume is very unlikely to be a year to year constant. In addition to the yearly production variations, a time (around year 2011) will come for Red Dog when ore grade will decline, and this would appear to invite consideration of numerous potential courses of action involving concentrate volume, including the following options:

Case 1. Do nothing regarding extraction rates and allow the amount of concentrate produced to decline consistent with the decline in ore grade. This would lead to a decline in gross income, cash flow, and return on the investment; however, the overall rate of return could still be maintained well above the company stated performance objective.

Case 2. Make quantity extraction adjustments necessary to continue concentrate production at 1,544,000 swt. This would allow gross income to be maintained at pre–2011 levels while allowing for a small decline in net cash flow as a consequence of incremental expansion cost possibly being higher than average cost and/or as a result of unmitigated productivity losses (diminishing returns).

Case 3. Make quantity extraction adjustments necessary to produce concentrates in an amount required to maintain net cash flow at pre–2011 levels, providing that the incremental adjustments could pass the company performance criteria for new investments.

This report presents a range of concentrate production possibilities as reasonable upper and lower bounds of the most likely future and selects a level of concentrate shipment, based on the quantity that will most likely provide a maximum net cash flow while supporting mining activity for at least 40 years. Concentrate production levels simulated were 1,352,000 swt, 1,544,000 swt, and 1,729,000 swt annually.

The company makes investment decisions with zinc prices assumed to be at $.45 lb which is somewhat lower than long-term average market prices but is a preferred choice for company decision makers because it builds a certain measure of safety into investment decisions which commit large amounts of capital for long periods of time. This report recognizes price possibilities up to $.56. lb. The mine is shown to have a positive net cash flow down to a zinc price range as low as $.305–$.35 lb.

Setting aside all of the associated non-quantified risks and ignoring production restraints, the production cost comparison indicates that a long-term production goal of 1,729,000 swt of concentrate will provide the highest net cash flow among the levels evaluated. This projected hypothetical production goal of 1,729,000 swt is considered to be a possible future, although not necessarily the most likely. As a possible future, it also produces an acceptable rate of return at a price expectation of $.45, providing expansion cost does not exceed average production cost.

Settling on a most likely future production level is in part a function of the economics of decisions relating to ore quality, quantity, overburden, location, incremental investment, etc., about which there are many unknowns. Among them is the principal uncertainty of eventually going underground for new resources, and this is considered to be a major cost-risk concern with the potential of offsetting the economics of any related expansion plan. At this point the unknown practical and economic limits of a new or different underground operation might introduce new limits to mine output regardless of market prices or incremental investment requirements. A most likely future production increase would have to account for the anticipated complex unknown cost and production circumstances surrounding expansion while developing an underground operation, and these factors are neither known nor quantified at the present time. Therefore in this report, the most likely output goal is anticipated to be maintained at 1,544,000 swt; a risk compensation level, which matches the presently developed system capacity, provides a 40 year mine life, provides an acceptable rate of return, and avoids costly bottlenecks that would result from forcing mine throughput above design capacity.

The following table compares net cash flow possibilities at different scales of production and different zinc prices. The first 1,544,000 swt column shows net cash flow at the present day design capacity of the mine given present day ore quality. The other columns represent net cash flow at various concentrate production levels after taking steps in response to an eventual decline in ore quality. Indications are that, with a long-term price expectation in the $.45–$.56 range, the best operating scale would be 1,544,000 swt annually.

**Table 105. Cash Flow Variations–Productivity Adjustments For Mine And Mill Operations For Case 3 Only**

| | Operating Net Cash Flow $Millions Annually | | | |
|---|---|---|---|---|
| | BASE | CASE 1 | CASE 2 | CASE 3 |
| | 2004 Baseline Production Target 1,544,000 swt | 2011 Quality Change No Adjustment Produces 1,352,000 swt | 2011 Quality Change Mine Maintains 1,544,000 swt | 2011 Quality Change Mine Produces 1,729,000 swt |
| @$0.45/lb | 177.7 | 142.7 | 156.7 | 119.1 |
| @ 0.47/lb | 201.2 | 163.4 | 180.5 | 145.8 |
| @ 0.50/lb | 236.5 | 194.5 | 216.2 | 185.8 |
| @ 0.53/lb | 271.8 | 225.5 | 251.9 | 225.8 |
| @ 0.56/lb | 307.0 | 256.6 | 287.5 | 265.8 |
| | Cost after Credits, Finished Zn c/lb | | | |
| | 30.5 | 32.8 | 32.1 | 36.4 |

All of the benefit categories, except fuel shipments, and the tug and barge cost, have a direct relationship to concentrate shipments, and all of them will change if concentrate shipments change. The following table summarizes the benefits as they were calculated for the most likely concentrate shipment level of 1,544,000 swt.

**Table 106. Benefits Of Alternative Plans Nominal 2004 Price Level ($Thousands)**

| Benefit Category | 1,352,000 Tons and T-C 53 ft | 1,544,000 swt and T-C 53 ft | 1,729,000 Tons and T-C 53 ft |
|---|---|---|---|
| Tug and Barge Cost | 10,788.3 | 10,788.3 | 10,788.3 |
| Port and Queue | 2,833.2 | 3,333.2 | 4,735.7 |
| Vessel Transit | 583.1 | 0 | (583.1) |
| Induced Tons | 0 | 1,707.9 | 7,299.2 |
| Fuel (Multi-Use) | 10,419.4 | 11,002.4 | 11,562.5 |
| Avoided Cost | 66.9 | 66.9 | 66.9 |
| Total | 24,690. 9 | 26,898. 7 | 33,869. 5 |

**Table 107. Alternative 11 At 50 ft, Sensitivity Of The Benefits To Variations In The Concentrate Projections ($Thousands)**

| Benefit Category | 1,352,000 Tons and T-C 50 ft | 1,544,000 swt and T-C 50 ft | 1,729,000Tons and T-C 50 ft |
|---|---|---|---|
| Tug and Barge Cost | 10,788.3 | 10,788.3 | 10,788.3 |
| Port and Queue | 2,833.2 | 3,324.4 | 4,774.7 |
| Vessel Transit | 1,399.0 | (991.0) | (1,399.0) |
| Induced Tons | 0 | 1,707.9 | 7,299.2 |
| Fuel (Multi-Use) | 10,419.4 | 11,002.4 | 11,562.5 |
| Avoided Cost | 66.9 | 66.9 | 66.9 |
| Total | 25,506.8 | 25,898.9 | 33,092.6 |

In the above table, tug and barge costs do not change because the fleet is present at-site for the duration of the season regardless of the number of tons shipped. Port and queue cost are sensitive because fewer tons means fewer ships to load. Queue cost is exacerbated as added vessels vie for limited loading capacity. Vessel transit costs are sensitive because fewer tons mean fewer ships are required. This is offset somewhat by channel depth limitations requiring added vessels. Induced tons are sensitive to changes in concentrate shipments, because induced tons exist only when the with-project condition allows shipment of tons in excess of tons shipped in the without-project condition. Fuel is sensitive because less mining activity consumes less fuel.

For the 53 ft channel, when all of the effects are added together, a 12% increase in the concentrate projection, above the most likely case, results in a 26% increase in project benefits, and a 12% decrease in the concentrate projection, below the most likely case, results in a 9% decrease in benefits.

**Maintenance Dredging Cycle**. Choice of the most likely maintenance dredging cycle is based on a cost-effectiveness comparison of more than one schedule. In other words the timing of maintenance dredging is based on arriving at the least costly combination of dredging operations necessary to provide a given minimum project dimension; the adopted maintenance dredging cycle will be the one identified as the least costly solution. Because the dredging regime has a set performance criteria, the benefits of the project do not vary as the maintenance cycle is changed; however, the overall economics of the project are impacted because of impacts on the project cost. Typically an adjustment in the dredging cycle will shift the amount of dredging periodically required from one year to another, and this will have some impact on project economics depending on the portion of annual costs that are dredging costs. For all of the trestle alternatives under consideration, maintenance dredging makes up a small part of the project annual cost and is not a significant concern to overall economic justification or to plan selection.

When looking at the cost of the dredging, there is also the present worth adjustment to future costs, which must be considered, because it has the affect of making them smaller in terms of present value equivalents. For example the present worth effect on a maintenance dredging cycle at year 1, year 10, and year 20 would be the difference in present worth cost of $1,$0.59, and $0.35. So the further off in time a maintenance cycle is shifted, the smaller the cost becomes and the higher the benefit-to-cost ratio becomes as a result.

There are limits to the timing options for scheduling maintenance dredging, because at some point, the project would become shallower than depths needed to pass the fleet, and project performance would eventually decline if allowed to do so. For any economically justified project, adverse effects on the project, resulting from shoaling, will always be greater than the cost of preventing the shoaling. For this reason dredging is scheduled inside of the time frame when shoaling could interfere with performance but still with the objective of maintaining the project dimensions.

Given the small band of the performance window and the small magnitude of maintenance dredging cost in any of the alternatives, the question of impact on the project economics is of no material consequence.

**Dedicated Fleet Tug and Barge Cost**. In the Economic Analysis Appendix, a distinction is made between economic or opportunity cost, financial or contract cost, and reconstructed cost. These distinctions are necessary because, in studies such as this, they can demonstrate a pronounced difference. The cost of the dedicated tug and barge fleet is a matter of importance, because some of the fleet cost is made unnecessary by the NED plan while some of the other project alternatives change the cost structure of the dedicated fleet in other ways. There is a difference of several million dollars annually between the actual contract/financial cost of the dedicated fleet and the reconstructed cost—the reconstructed cost being lower.

There are numerous data and methodology differences which go into the derivation of the fleet cost including those presented in company data, those within Corps database sources, and those within various cost estimating methods. Probably the single variable, having the largest impact on cost of the tugs and which appears as a factor in all sources, is fuel cost, making up about 25% of tug total hourly cost based on Corps data[143] and 34%, based on the cost reconstruction in this report; it is somewhat less of the hourly cost of the self-unloading barges.

Fuel cost follows crude oil prices, which are determined largely in an international marketplace by the balance between production in OPEC and non-OPEC nations, and world demand. Crude oil makes up around 42% of the market price of fuel oil. In the EIA reference case, the average lower 48 crude oil price is projected to be $24.28 per barrel in 2010 and $27.00 per barrel in 2025.[144] In the EIA high world oil price case, the lower 48 crude oil price increases to $33.27 per barrel in 2010 and $35.03 per barrel in 2025. In the low world oil price case, the lower 48 price generally declines to $16.98 per barrel in 2010 and then rises to $16.98 per barrel in 2025. These EIA projections translate to a range of heating oil prices ranging from $0.96/gallon to $1.89/gallon in 2010.

[143] EGM 00-5 FY 2000 Shallow Draft Vessel Operating Cost accessed at http://www.usace.army.mil/inet/functions/cw/cecwp/General_guidance/guidance.htm.

[144] Annual Energy Outlook 2004 With Projections To 2025, Report #: DOE/EIA-0383 (2004), accessed at http://www.eia.doe.gov%20and%20energy%20outlook.

Comparisons with other oil price forecasts, including GII (Global Insight Incorporated), the International Energy Agency (IEA), Petroleum Economics, Ltd. (PEL), Petroleum Industry Research Associates, Inc. (PIRA), Natural Resources Canada (NRC), Deutsche Bank A.G. (DB), Energy and Environmental Analysis, Inc. (EEA), National Petroleum Council (NPC), Strategic Energy & Economic Research, Inc. (SEER), and Centre for Global Energy Studies (CGES), are shown in the following table.

**Table 108. Energy Price Forecast Comparison**

| Forecast | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| EIA, AEO 2004 | | | | | |
| Reference | 23.30 | 24.17 | 25.07 | 26.02 | 27.00 |
| High price | 31.16 | 33.27 | 34.23 | 34.63 | 35.03 |
| Low price | 16.98 | 16.98 | 16.98 | 16.98 | 16.98 |
| GII | 21.77 | 21.95 | 24.03 | 25.68 | 27.06 |
| IEA | 21.75 | 21.75 | 23.82 | 25.89 | 27.96 |
| PEL | 20.96 | 21.27 | 18.41 | 15.60 | NA |
| PIRA | 23.80 | 23.90 | 26.70 | N/A | NA |
| NRCan | 22.57 | 22.57 | 22.57 | 22.57 | NA |
| DB | 18.13 | 18.03 | 18.41 | 18.16 | 18.26 |
| EEA | 20.99 | 20.33 | 19.84 | 19.36 | NA |
| NPC | 18.00 | 18.00 | 18.00 | 18.00 | 18.00 |
| SEER | 21.08 | 19.86 | 20.88 | 22.49 | 24.53 |
| CGES | 23.82 | 21.27 | 18.41 | 15.60 | NA |

NA = not available

The world oil price measure varies by forecast. In some, it is the spot price for West Texas Intermediate (WTI), Brent, or a basket of crude oils. There is no simple way to put the forecasts for oil prices on a common basis. The range projections of EIA span the low to high of all of the others except CGES, which has the lowest projection for 2025. The average of the EIA low and high for 2005 is $1.37 and $1.42 in 2010. This is consistent with this report which used a value of $1.40 per gallon, based on actual prices of refined products used in the marine transportation industry within northwest Alaska.

The $1.40 per gallon is supported by actual regional fuel sales records and local cost factors incorporated in Corps' manual EP 1110-1-8. The source for documentation of sales is Economics Data Program, Pacific States Marine Commission, which lists weekly information on fuel sales at Adak, Akutan, Cordova, Dillingham, Dutch Harbor, Homer, Kodiak, Naknek, Seward, Homer, and St. Paul. Sales at these locations averaged $1.41 per gallon over the 2001 year. During the course of the year, fuel prices at those locations fluctuated between $1.30 and $1.58, making the mean of the extremes $1.44 per gallon and indicating $1.40 to be a reasonable although possibly slightly understated representation of marine diesel fuel prices at arctic locations. Fuel sales at all Alaska ports averaged $1.40 per gallon over 2000 through 2003. The sample data was cut off at the end of 2003 to minimize market distortions caused by international strife, centralized in oil rich exporting countries of the Persian Gulf.

Regarding the dedicated fleet, the operating practice of the equipment owner is to fuel the equipment at Seattle during the season mobilization, and this includes filling the tugs and the barge tanks with fuel adequate to operate the tugs and barges throughout the entire season. The financial out of pocket cost for marine diesel at Seattle is estimated at $1.07 from a wide range of values. This is derived from sources accessed during year 2001; however, in 2002 TCAK indicated the average cost of fuel through their rate agreement was $1.01.

Using the vessel operating cost data prepared for the Economic Analysis Appendix, and using a 4,000 HP tug as representative of the scale of impacts on the fleet, if the diesel fuel price of $1.07 instead of $1.40 were to be used as a basis for calculating annual cost of the tugs, the annual operating cost of the tug fleet would be decreased by about 8%, and if the maximum diesel fuel price of $1.58 is used, cost of the tug fleet will increase by about 4% giving a 12% band enveloping the costs derived using the selected value of $1.40 per gallon. Stated another way, a 24% decrease in fuel price will lead to a 8% decrease in tug operating cost, and a 13% increase in fuel cost will lead to a 4% increase in tug operating cost.

Total annualized benefits associated with a reduction in tug and barge fleet costs are $10,788,300. Of this about $5,204,700 is for four tugs. The low-high range of variations in fuel cost would subtract $416,400 or add $208,200. Though these may appear to be large amounts of money, in the context of impacts on project justification or plan formulation, they are unimportant. The low-high range benefits for the category would be **$10,371,900–$10,996,500** respectively.

The foregoing relationship between fuel cost and tug operating cost holds also for the with-project condition; however, the with-project condition will have varying numbers of tugs and barges, depending on the alternative being evaluated, and the option of fueling at Seattle for the season could disappear. To the extent that there are varying numbers of tugs and barges, there are differences among the total costs of each of the alternatives. Nevertheless the magnitude of difference caused by varying the fuel cost per gallon is so inconsequential as to not warrant a drawn out presentation. This is because, in the benefit evaluation, fuel prices would be adjusted in the same direction by a similar percentage for the without-project condition and any with-project condition (other than losing the option of fueling at Seattle for the season). Since benefits are the difference between the two conditions, little change in overall benefits of the NED plan would be evident outside of the negligible impact on the dedicated tug and barge fleet.

**Induced Tonnage.** In this study there is adequate data to determine that there is only one level of induced movement and one willingness-to-pay (WTP), because without the project, there is neither an alternative mode nor an alternative port; with the project, there is only one level of shipment that maximizes net income consistent with the shipper's management, investment, and operational strategy. Nevertheless, in the interest of recognizing that one would ordinarily anticipate numerous levels of induced movement (ordinarily there would be numerous affected suppliers) at increments of WTP, an average WTP was used for the expected average transportation cost that could be borne by the induced traffic. This was assumed to be half way between the highest and lowest costs at which any part of the induced traffic would move having the effect of reducing the estimated WTP by half.

This reduction and its result are designated as a "most likely" case because doing so is consistent with Corps' guidance regarding the benefit evaluation. Beyond this guidance, however, in terms of market realities, it could be regarded as representative of a "low case" estimate. The downward adjusted value overlooks the absence of competition at the site and overlooks the lack of alternative shipping facilities, modes, or routes. Without competition a sticky price is likely to prevail. With adjustments for a 31-year benefit stream out of a 50-year project life, doing away with the adjustment increases NED benefits by $1,707,900 to **$3,415,800** for each of the depth variations of Alternative 11.

**Reduction of Risk in the Concentrate Loading Operation.** In this report, reconstruction of tug and barge cost is the basis for savings achieved by substituting a deep draft channel, trestle, and conveyor for the tug and barge fleet. None of the cost reconstruction incorporates potential net income losses (costs), resulting from risk events that would put the tugs and/or barges out of service. Therefore, the benefit calculation does not account for reduction of risk from doing away with the offshore self-unloading system.

There is some contention that the tug and barge operation poses a higher risk of outage than would the channel-trestle-conveyor operation. This perception is based on TCAK experience with similar transfer and loading operations around the world and at Portsite. In contrast to the channel-trestle-conveyor system, the tugs and barges have to make an annual round-trip from winter quarters at a Puget Sound location, which requires passing through the Gulf of Alaska and the Bering Sea. In addition, while at Portsite, they must operate in an open roadstead environment. The self-unloading barges are unique units, so if they are damaged at sea or in route, there is no substitute and as a consequence, the mine would shut down when surge storage is full. Any event that results in putting the self-unloading barges out of service has huge financial consequences in terms of the mine's lost net cash flow.

There was inference during report preparation that the shipping contract which was arrived at through market devices included compensation for risk. The proposition was based on competitively derived market agreements being an indication of long-run costs, and in resource economics, long-run costs are the best indicator of opportunity cost.[145]

However, Independent Technical Review of an early draft of this report and HQ guidance received during preparation of this report rejected using any part of the shipping cost agreement in connection with estimation of NED benefits of risk reduction. Of the several issues introduced were that the contract appeared to be a rate agreement and not a negotiated price and that the nature and consequences of the risk were not clearly accounted for. Resolution was handicapped by the parties not being granted access to confidential contract information. Other proposed evaluation procedures were judged to lack statistical data adequate to produce a meaningful probabilistic analysis so the benefit category was dropped from the draft report.

For a risk analysis of the units in question, there is no known directly applicable, comprehensive U.S. statistical database of barge and tug casualty loss by event and location. However, as a basis for inference, there is data available from the Canadian Transportation Board, including barge operations in north Pacific waters of Canada. The north Pacific waters of Canada are generally a

[145] Economic And Environmental Principles And Guidelines For Water And Related Land Resources Implementation Studies, Water Resources Council, March 1983, Para 2.6.2 "In competitive markets, rates (prices) correspond to marginal cost, and, given market stability, prices will settle at long-run marginal costs ... In the case of existing waterways, prevailing competitive similar rates are the best available approximation of long-run Marginal costs." And Para 2.12.2 (b) ..." The opportunity costs of resource use are usually reflected in the marketplace. When market prices adequately reflect total resource values, they are used to determine NED costs. When market prices do not reflect total resource values, surrogate values are used appropriately to adjust or replace market prices."

more seafarer friendly environment then the Gulf of Alaska and Bering Sea, and the data is used here to provide a conservative background for the tug-barge risk issues.

Essentially the Canadian data is used to show the type of event involved in marine accidents and also to illustrate the number of accidents involving tug and barge equipment. The statistics are summarized here for the most recent ten years of data available. The first data summary identifies the frequency of events by type of event, and the second identifies the type of vessel involved.

**Table 109. Canadian Marine Accidents By Type Of Event[146]**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Shipping Accidents by Type | 710 | 796 | 698 | 607 | 534 | 491 | 536 | 450 | 458 | 447 | 572.7 |
| Collision | 27 | 40 | 20 | 20 | 15 | 15 | 22 | 16 | 16 | 15 | 20.6 |
| Capsizing | 20 | 18 | 27 | 19 | 21 | 13 | 6 | 15 | 6 | 14 | 15.9 |
| Foundering/Sinking | 43 | 56 | 55 | 42 | 36 | 28 | 32 | 38 | 37 | 26 | 39.3 |
| Fire/Explosion | 81 | 91 | 85 | 98 | 73 | 65 | 70 | 64 | 84 | 52 | 76.3 |
| Grounding | 168 | 176 | 159 | 143 | 126 | 128 | 146 | 123 | 114 | 129 | 141.2 |
| Striking | 113 | 112 | 138 | 90 | 88 | 85 | 85 | 68 | 88 | 71 | 93.8 |
| Ice damage | 35 | 30 | 15 | 22 | 23 | 11 | 10 | 6 | 4 | 2 | 15.8 |
| Propeller/Rudder/Structural Damage | 86 | 89 | 57 | 5 | 30 | 25 | 40 | 31 | 19 | 43 | |
| Flooding | 48 | 94 | 79 | 61 | 69 | 69 | 65 | 51 | 70 | 52 | 65.8 |
| Other | 89 | 90 | 63 | 62 | 53 | 52 | 60 | 38 | 20 | 43 | 57 |
| Accidents Aboard Ship | 67 | 67 | 56 | 58 | 60 | 59 | 69 | 77 | 59 | 36 | 60.8 |

**Table 110. Canadian Marine Accidents By Type Of Vessel**

| Type of Vessel | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cargo | 41 | 48 | 34 | 29 | 21 | 26 | 26 | 25 | 31 | 23 | 30.4 |
| Bulk Carrier/OBO | 132 | 141 | 123 | 98 | 61 | 68 | 73 | 59 | 57 | 57 | 86.9 |
| Tanker | 25 | 26 | 15 | 24 | 13 | 18 | 14 | 14 | 12 | 9 | 17 |
| Tug | 44 | 57 | 51 | 45 | 38 | 42 | 42 | 33 | 39 | 24 | 41.5 |
| Barge | 34 | 42 | 51 | 43 | 31 | 25 | 35 | 30 | 28 | 31 | 35 |
| Ferry | 29 | 28 | 27 | 22 | 17 | 23 | 22 | 26 | 24 | 21 | 23.9 |
| Passenger | 20 | 17 | 22 | 21 | 16 | 27 | 20 | 20 | 16 | 26 | 20.5 |
| Fishing | 380 | 444 | 389 | 322 | 319 | 251 | 280 | 238 | 246 | 237 | 310.6[147] |
| Service Vessel | 31 | 44 | 36 | 24 | 30 | 27 | 35 | 23 | 27 | 19 | 29.6 |
| Non-commercial | 32 | 23 | 28 | 15 | 13 | 19 | 14 | 13 | 18 | 20 | 19.5 |
| Other | 11 | 11 | 3 | 14 | 17 | 8 | 20 | 11 | 8 | 14 | 11.7 |

[146] Transportation Safety Board of Canada, Information Strategies and Analysis Directorate, Place du Centre, 200 Promenade du Portage, 4th Floor, Gatineau, Quebec, K1A 1K8 accessed at http://www.tsb.gc.ca/en/stats/marine/2003/marine03_appendix_a.asp#Table_1.

[147] Note accidents among commercial fishing vessels outnumber tug and barge accidents by 4:1 for Canadian waters overall and by over 3:1 in the Western Region (Pacific Coast). The Western Region accident to loss ratio is 8:1 for all vessel types.

**Table 111. Vessels Involved In Canada Western Region Shipping Accidents**

| | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Shipping Accidents | 264 | 299 | 247 | 208 | 183 | 196 | 168 | 166 | 158 | 139 | 202.8 |
| Accidents Aboard Ship | 19 | 20 | 11 | 15 | 18 | 14 | 18 | 32 | 29 | 15 | 19.1 |
| Vessels Involved in Shipping Accidents by Type of Vessel | 298 | 346 | 278 | 218 | 202 | 213 | 181 | 177 | 179 | 155 | 224.7 |
| Cargo/OBO/ Tanker | 25 | 18 | 9 | 9 | 13 | 10 | 11 | 9 | 10 | 3 | 11.7 |
| Ferry/ Passenger | 9 | 15 | 13 | 14 | 12 | 14 | 10 | 18 | 15 | 18 | 13.8 |
| Tug/Barge | 49 | 58 | 44 | 43 | 29 | 44 | 40 | 44 | 39 | 32 | 42.2 |
| Fishing | 195 | 234 | 194 | 142 | 133 | 128 | 102 | 93 | 98 | 78 | 139.7 |
| Other | 20 | 21 | 18 | 10 | 15 | 17 | 18 | 13 | 17 | 24 | 17.3 |
| Vessels Lost | 40 | 41 | 37 | 30 | 20 | 25 | 19 | 14 | 22 | 13 | 26.1 |
| Fatalities | 17 | 19 | 14 | 8 | 7 | 6 | 10 | 10 | 12 | 10 | 11.3 |
| Incidents | 91 | 69 | 51 | 43 | 41 | 54 | 57 | 110 | 122 | 85 | 72.3 |

The Canadian database also states the accident rate for commercial vessels over the decade (not shown), and it averages out to 4 accidents per 1,000 vessel trips. Using the Canada Western Region data, which includes the West Coast of British Columbia, the loss rate per accident is 13%. It follows that, without any adjustment and transferring the data directly to the Portsite situation, for the 372 vessel trips to be made by Portsite equipment over the relevant 31-year period, one could expect 1.5 accidents with a 13% chance of total loss.

However, the Portsite situation is not comparable, and the above estimate needs to be adjusted for risk factors not inherent in the Canadian circumstances but presumed to be present in the Alaska operation. Lacking a suitable statistical basis, the following subjective adjustments are indicated:

- The trip from Puget Sound to Portsite is 5 times longer than the Canadian West Coast = (5x).
- About half of the Canadian coast is protected waters while the Portsite trip is in a far more risky open water environment of the Gulf of Alaska and Bering Sea =(2x).[148]
- A normal storm track, along the Aleutian Island chain, the Alaska Peninsula, and all of the coastal area of the Gulf of Alaska, exposes the barge route to storms crossing the North Pacific, with frequent winds in excess of 50 mph and peak annual winds in the 80–90 mph range.[149] Hurricane classification starts at wind speeds of 74 mph. Outside of Alaska, the entire U.S. experiences only about 1–4 hurricanes per year = (2x).[150]
- Canadian ports are close together so shelter and rescue options are more readily available = (.25x).

The above subjective factors are not scientifically or statistically derived. They total 9.25 if equally weighted. They imply that the incident frequency for the Portsite equipment

[148] Alaska Fisherman's Journal, Vol 27, Number 7, July 2004. Rear Admiral James Underwood, in reports of a public ceremony of USCG honors of heroism, ".and the Bering Sea is the hardest of them all."

[149] Air Force Combat Climatology Center, period of record 1973–1997 used as source data for planned navigation improvements at Unalaska in 2001.

[150] see http://encarta.msn.com/encyclopedia_761565992/Hurricane.html 1944-1969 averaged 2.7; 1970-1994 averaged 1.5, and 1995–2003 averaged 3.55.

approximates 14 events during the 31-year period. This translates to potential expectations of about 2 equipment loss or major damage events during 31 years, a 6% expectation.

Risk exposure is predominately in route to or from Portsite. Half the trips are to the site so it is reasonable to accept the view that as a loss consequence, a significant number of tons could be left unshipped in at least one year. If both barges were to be disabled in route, this could curtail mine production and shipments for an entire season.

As a boundary check of the above risk estimate, it was compared against an approach keyed to the Alaska fishing vessel database. The Alaska fishing vessel casualty loss data averages 44 per year.[151] Lacking any other statistical approach, it was assumed that the relation between Canadian tug and barge losses, and Canadian commercial fishing vessel losses, a ratio of 1:3 could be used to estimate risk, related to the Portsite fleet by applying the Canadian ratio to casualty losses from the Alaska commercial fishing vessel records. The suitability of this data transfer is not statistically confirmed; however, the result indicates an upper limit of about 15 tug/barge events per year among all vessels transiting Alaska waters. Given that there are estimated to be over 500 commercial tug/barge units operating in Alaska waters, the implied 3% expected loss rate for the entire fleet bears a reasonable comparison with the estimated annual risk for the 372 Portsite vessel trips (2 loss or major damage/31 years = 6% expected annual loss).

As another check of the risk situation, one can examine the actual Portsite performance history and discover that, in 12-years of operation, there was one barge lost from service due to hazards of the sea. This happened near the end of the loading season, and the remaining barge was able to finish loading the last deep draft vessel of the season. This is about an 8% frequency of events (1 in 12 years) and is used here as a high range estimate. A potential for loss of one vessel in 12 years compares reasonably with the foregoing estimated potential of 2 units over 31 years.

Damage to the concentrate loading equipment would disrupt mine operations and lead to loss of net cash flow to TCAK. The loss, however, would be made-up in year 2043 when the mine's operation could be extended instead of closing due to resource limitations. A present worth adjustment reduces value of the net cash flow made up in 2043 to 20% of its 2043 value. In a year with zinc at $.53 lb. net cash flow amounts to $251,900,000 (see table 107). An 80% loss in net cash flow (used as a substitute for net income) in any one year amounts to $201,520,000.

Using the higher end risk, an 8% chance of loss events, affecting one barge (half the loading capacity), reduces the potential loss to an expected annual value of $8,060,800. Assuming the loss is incurred at mid-season, the expected annual loss value is adjusted down by half to **$4,030,400**. The estimated annual loss value could vary widely depending on weather limitations before and after the loss event.

For a low range estimate the expected annual chance of loss of a barge is pegged at 6%. Given a 6% frequency, the annual risk cost is **$3,022,800**.

[151] Personal notes, and unpublished data not for public disclosure provided by USCG. Data relates to over 600 loss events in Alaska waters.

None of the above estimates, account for the cost of repair and/or replacement which would increase the financial cost of the risk. Damages after the end of the season or during the time that the units are in winter storage are discounted to zero.

**First Cost of the Trestle.** Depending on the trestle alternative under consideration, the investment cost of the trestle can make up between 69%–79% of the total investment in variations of Alternative 11. Its cost, therefore, has a major tie in with the overall project economics; however, the benefits of this particular port improvement are so large as to mitigate the economic justification effects of a capital cost adjustment. One could actually increase the capital cost of the trestle by about 30% and still demonstrate economic justification if that is the only change. Typically, changes affecting project cost over time will also affect benefits, thus canceling each other out. A scenario or chain of events, resulting in an adjustment of such a magnitude to trestle cost only, is beyond what one can reasonably imagine and explain.

Adjustments in the first cost of the trestle probably have a more significant relationship to cost sharing and sponsor interest than to NED economic justification, because justification of the NED plan is not at risk. The cost of the trestle, however, is a non-federal cost and must be carried 100% by others. This distribution of a large associated cost to the non-federal interests, cooperating in the project, has had the effect of creating a great deal of external expert participation in design and cost analysis. Essentially, this spreading of the risk has resulted in an informal but continual and serious outside peer review, serving to narrow down the band of uncertainty around the cost estimate for the trestle components.

All of the project components include contingency allowances. For the trestle the combined contingency adjusts the total upward by 20%, but there is no downward contingency. Implied in this approach is that some items outside of the specific line items must be allowed for in order to allow the work to be completed and that specific data used in the estimate actually represents a range of possibilities. This would make the total, before adding a contingency, somewhat less than what one would anticipate a reasonable "most likely" estimate to be. Through inclusion of the cost contingency, the most likely estimate is, in a sense, a realistic value while the estimate, without a contingency attached, could be considered a low range number, although probably not valid.

First cost of the trestle will vary as different design concepts are applied; however, there has been a significant amount of design work done on several different trestle plans. The trestle costs were by AMEC, a company with world-wide experience in construction and operation of marine terminals. They have numerous facilities standing, and they also have business ties with TCAK. An inaccurate or weakly supported or incomplete estimate could have direct economic repercussions on AMEC. Company prosperity depends on continued demonstration of its expertise. For that reason and the large amount of technical research the company has expended on Portsite, the estimate is presumed to be of unusually high quality, and prospects of variation beyond normal expectations are considered to be remote.

**Fuel Savings Per Gallon.** Heating oil is a U.S. middle distillate petroleum product, used primarily for residential heating, and is also known as gasoil for a number of other uses, including use as transportation fuel. Other petroleum products such as jet fuel and unleaded gasoline are also brought into the region by barge, but they make up only about 10% of the total shipment. Heating oil prices are affected by:

- Crude oil prices.
- Seasonality—meaning that heating oil is normally more expensive during the winter months in the U.S. and Europe. The Asian market is less affected by seasonality, except in countries, such as Japan and Korea, which also have four seasons in a year.
- Rapid and unpredictable changes in temperature, which can have a serious impact on heating oil stocks.
- The price of competing products, for example natural gas. When natural gas prices get unusually expensive, some companies may switch to cheaper alternative fuels, including heating oil. The year 2000 surge in U.S. heating oil prices was attributed to marketers substituting it for natural gas.
- Production efficiency of the refinery.

The price of fuel and the saving per gallon, brought about by Portsite project, is woven into many aspects of the economic assessment, and within the analysis, some of the effects of achieving a lower fuel price combine with other project savings in complex ways. One way to show the sensitivity of a different level of fuel price savings would be to use the possible range of fuel prices throughout an entire replication of the economic analysis; however, this generates wide ranges of outcomes still leaving one to select a most likely value. Such a range of values can be narrowed down by selecting a most likely value methodically from informed choices as the analysis progresses.

It is easy to identify the parts of the benefit analysis that are linked to heavy use of fuel, and they are the most obvious place where the sensitivity of the results to changes in cost of fuel can be tested. The fuel cost savings benefit is based on a comparison of west coast U.S. prices against prices in Singapore which is considered to be a relevant comparison, because in the without-project condition, fuel comes from the west coast, and in the with-project condition, it comes from Singapore. Savings stemming from foreign fuel purchase is made possible by the Portsite project, because Portsite project makes use of deep draft tankers, possible cutting the delivery cost and making a lower priced point of purchase accessible.

The feasibility report economics is based on expectation of a most likely fuel price reduction in purchase cost of $.15 per gallon, which is the historic five year average difference in purchase price between the point of purchase without a DMT project (Puget Sound or Kenai Peninsula) and with it (Singapore). In both cases the point of purchase is the lowest cost option, in the sense, that it offers the lowest delivered destination price when both the purchase price and transportation cost are included.

For purposes of this sensitivity test, there is no obvious or well defined upper and lower bound to the most likely fuel cost savings, because as one would expect, the data fluctuates daily. For purposes of estimating a reasonable upper and lower bound, consideration was given to securing market data from different sources. Other sources could help verify whether the asserted $.15 savings differential is reasonable and defensible and to see if there is a statistical basis for stating an upper and lower bound to the saving range. For purposes of the sensitivity analysis, this alternative source approach was discarded in favor of a more direct test of the sensitivity of the results to hypothetical changes in the amount of saving per gallon, because the intent of the sensitivity analysis is not to verify basic inputs but to test how the results of the study would vary as a result of variations of the input values. Notwithstanding this, enough work was done on price expectations from alternative sources to provide insight into the reasonable upper and lower range of the saving differential.

It is clear that adjustment of the oil price savings upward from the $.15 would only serve to enhance the economics of the recommended plan without changing the plan formulation. A severe downward adjustment in the oil price saving would have a somewhat more complicated effect on the analysis. This is because, at some threshold, a smaller oil price saving could shorten the radius within which delivery through Portsite will be the lowest cost delivery option. A smaller saving radius will lead to fewer customers, resulting in less fuel being delivered, and this reduction in total gallons shipped through Portsite will have an adverse effect on the benefit calculation.

The oil price savings per gallon would need to decline by $.13 to $.02 per gallon to result in a reduction in the delivery radius. At a saving differential under about $.02, the delivery scenario is a borderline option for the Nome hub and some of the more distant villages destinations, so savings to them would begin to disappear. More important, a reduction to a total savings to $.02 per gallon has the associated consequence of reducing $13,173,700 savings for delivery of up to 58,746,700 gallons by about $7,677,000 (see table 73). The benefit adjustment is not straight forward, because transportation cost savings, due to use of a deep draft tanker, would be unchanged; the balance of savings would occur over different time patterns for the mine and the villages; the radius would adjust. In the 15 years of sales data examined, the average differential has never approached this low value. It is regarded as too extreme to provide a basis for a low range scenario.

The savings per gallon of fuel could fall by over $.03 per gallon while still maintaining economic justification of the plan. It should be noted that, even if the purchase price is the same with the project and without it (a fuel price purchase price saving of $0/gallon), there is still a $.06 gallon saving due to the economies of scale attributable to delivery by deep draft tanker instead of by ocean barge. This however makes up only 32% of the fuel savings differential (see table 73).

The savings differential has been edging up over the last 15 years due to economic advantages (newer highly efficient refineries abroad, far flung modern port facilities, maturing connections to crude sources, etc.), and the trend is anticipated to continue. The United States has aged and outmoded refinery capacity that is not cost-competitive. The present day (3-year average) foreign-domestic price differential at $.15 can be viewed as the most likely low range by the project online date of 2011, because it is unlikely that United States refinery capacity will be expanded. This results in an annualized benefit for the category of **$11,002,400**. The cost per gallon gap is anticipated to increase with time and push the benefits to higher numbers, although the most likely fuel price differential used in this report is based on present day market information. For sensitivity purposes, a high range of $.20 has been selected. It is easily reachable before 2011 and results in an overall increase in benefits for the category to **$13,347,800**.

**Number of Gallons of Fuel Used by the Mine and Villages**. The feasibility report narrows down the fuel use projection to 58,746,700 gallons. There is recognition that the projected use at Red Dog is a function of mine production levels which could range from 1,544,000 to 1,729,000 swt of concentrate annually with the lower figure being considered to be the most likely. At those production levels, assuming no major modifications and an eventual degrading of ore deposits, the mine will require 25,921,400 gallons (88,130 tons)–29,064,100 gallons (98,800 tons) per year respectively. Fuel consumption per ton at various historical output levels is considered to be well documented with estimated consumption at the two projected output levels being the result of a mine cost simulator. Beyond modeling the mine and using the model output to estimate factors of production such as fuel requirements, actual mine fuel use records were examined and related to fuel consumed per ton of concentrate produced.

There is less certainty in the estimated amount of fuel to be used at various villages than there is at the mine; however, this uncertainty is mitigated by excluding any projected future increase beyond present day use. One problem in estimating village use is that the quality of data and amount of data varies among the villages. For example fuel use at Nome and Kotzebue is well documented, but fuel use at most of the region's smaller villages is not well recorded. Where village consumption is estimated, it is calculated based on a relation between gallons consumed and number of jobs, based on data from similar sample villages with good records.

The village fuel consumption estimate is based on the state Department of Community and Economic Development database for number of jobs in each village and multiplying that by the consumption per job from the sample data provided for similar small villages. The data for 9 small coastal villages indicated consumption per employee at 2,900 gallons per employee. In contrast, consumption per employee at Nome is 5,500 gallons and at Kotzebue is 4,780 gallons; however, consumption rates at regional economic, transportation, and health and government centers are asserted to be untypical of smaller coastal villages.

The estimates for village use represent selection of a most likely representation of the range considered and in many cases happens to be the low end of the range. For purposes of testing the sensitivity of the benefits to changes in the expected fuel consumption, range values have been identified based on the following:

**Table 112. Range Estimates Criteria For Fuel Use**

| Locality | Measure |
|---|---|
| Kotzebue | Basic data is reliable so arbitrarily select + -10% |
| Kotzebue area Villages | Range reflects per employee use data from Kotzebue as a high estimate and small villages as a low estimate. |
| 5 Swing Villages | Range reflects per employee use data from Kotzebue as a high estimate and small villages as a low estimate |
| Nome | Basic data is reliable so arbitrarily select + -10% |
| Nome area Villages | Range reflects per employee use data from Nome as a high estimate and small villages as a low estimate |
| Village Direct | Basic data is reliable so arbitrarily select + -10% |
| 7 Yukon Swing Villages | Range reflects per employee use data from Nome as a high estimate and small villages as a low estimate |
| Yukon Delta River | Range reflects per employee use data from Nome as a high estimate and small villages as a low estimate |
| Red Dog Mine | Based on varying output levels as simulated. |

When the above criteria are applied, the spread of gallons, estimated to be consumed in the with-project condition, range from a low of 49,982,400 to a high of 64,150,900.

**Table 113. Summary Of With-Project Condition Fuel Delivery By Water**

| | Tons per Year | | |
|---|---|---|---|
| Village | Low Estimate | Most Likely | High Estimate |
| Kotzebue | 18,360 | 20,400 | 22,440 |
| Kotzebue area Villages | 5,950 | 5,950 | 9,810 |
| 5 Swing Villages | 21,850 | 21,850 | 36,020 |
| Nome | 30,000 | 34,000 | 37,400 |
| Nome area Villages | 4,760 | 4,760 | 9,030 |
| Village Direct | 9240 | 10,270 | 11,300 |
| 7 Yukon Swing Villages | 6,330 | 6,330 | 12,000 |
| Yukon Delta, River | 12,800 | 12,800 | 24,300 |
| Red Dog Mine | 66,600 | 88,130 | 98,800 |
| Total | 175,890 tons shown with 169,940 tons (49,982,400 gallons) delivered to Portsite | 204,490 tons shown with 199,740 tons (58,746,700 gallons) delivered to Portsite | 261,100 tons shown with 251,290 tons (73,908,800 gallons) delivered to Portsite |

**Table 114. High Range Sensitivity Of Fuel Cost Savings To Changes In Fuel Use Rates**

| ITEM | Baseline Fuel Cost Savings ($) | High Range Factor | High Range Savings ($) |
|---|---|---|---|
| Delivery to DMT and Kotzebue | 2,110,700 | 1.1 | 2,364,000 |
| Nome | 684,100 | 1.1 | 752,500 |
| Village Direct | 257,900 | 1.1 | 283,700 |
| Swing Villages | 1,088,900 | 1.65 | 1,796,700 |
| Yukon Villages | 0 | 1.9 | 0 |
| Yukon Swing Villages | 167,800 | 1.9 | 318,800 |
| Lighters | 54,300 | - | 54,300 |
| Fuel Cost | 8,812,000 | 1.26 | 11,103,100 |
| Total Fuel Savings | 13,173,700 | | 16,673,100 |
| Annualized Benefit | 11,002,400 | | 13,925,000 |

**Table 115. Low Range Sensitivity Of Fuel Cost Savings To Changes In Fuel Use Rates**

| ITEM | Baseline Fuel Cost Savings ($) | Low Range Factor | Low Range Benefit ($) |
|---|---|---|---|
| Delivery to DMT and Kotzebue | 2,110,700 | .78 | 1,646,300 |
| Cost to Nome | 684,100 | .9 | 615,700 |
| Village Direct | 257,900 | .9 | 232,100 |
| Swing Villages | 1,088,900 | 1 | 1,088,900 |
| Yukon Villages | 0 | 1 | 0 |
| Yukon Swing Villages | 167,800 | 1 | 167,800 |
| Lighters | 54,300 | - | 54,300 |
| Fuel Cost | 8,812,000 | .85 | 7,490,200 |
| Total Fuel Savings | 13,173,700 | | 11,295,300 |
| Annualized Benefit | 11,002,400 | | 9,375,100 |

The annual fuel benefit is **$11,002,400,** and this total would be reduced to **$9,375,100** annually with the low range estimate and increased to **$13,925,000** through use of the high range estimate.

**Transportation Cost Savings of Moving Fuel from Portsite to the Villages**. The transportation savings attributable to use of lighters to move fuel to final destinations makes up only $54,300 of the total $11,002,400 fuel transportation benefit, less than ½ of 1%, and only about .2% of benefits of the NED plan. Given the magnitude of this saving, it is unnecessary to test the sensitivity of the benefits to changes in the analysis of lighters. Either doubling the amount or cutting it in half would have a barely perceptible effect on the economic justification.

**Ship Arrival Schedule**. During the various applications of the ship simulation model, it was thought that alternative interpretations of the ship arrival pattern would have a large impact on the queue. To test the sensitivity of the output, to changes in interpretation of the arrival schedule, two patterns were tested by comparing the without-project condition against Portsite 53 ft project:

- The without-project condition at 1,544,000 swt and DMT 53 ft project with ship arrival at regular intervals plus or minus 2 days. This is the historical pattern of all arrivals from 1996–1999.
- The without-project condition at 1,544,000 swt and DMT 53 ft project with ship arrival up to 4 days early and only one day late.

The results showed very little difference in the output indicating that variations in the arrival schedule are not a matter of concern. In the without-project condition, the difference between the two cases was 12.3 days compared to 12.1 days. For Portsite Alternative 11, there was no change.

**Tractor Tugs vs. Regular Line-haul Tugs**. During the WES model study, there was a conclusion that conventional tugs are not an option, and tractor tugs are a necessity. This distinction has little impact on the economics, because the ship simulator inputs are consistent with the WES model data and output thereby effectively incorporating the use of tractor tugs in the queuing simulation.

With regard to cost, the cost of a cycloid, Z drive, Kort, or a conventional drive is anticipated to not be much different by 2011 (project year 1). A few years ago there was quite a difference for Z and cycloid drives, because it was new technology; but in 2004, Z drives are very close to the cost of conventional drive units, and in some cases, they are cheaper. Currently there appears to be no shortage of Z drive or cycloids; for example Crowley has 13 cycloids at last count. There are even small tugs (under 2000 HP) with the cycloid units. All types of drives are in demand and being built; however, the Z drive has become the more popular tractor design.

Conventional drives are still meeting other needs, and the demand for them is keeping their prices somewhat comparable with Z drives which are continually declining in price. In some harbor applications, the tractor designs exceed pulling and stopping capability of the standard screw type used for line-haul. This allows a smaller tractor tug to be substituted for a larger line-haul tug in harbor applications—up to 40% smaller. Consequently, the tractor tugs are considered to be more cost-effective.

Regarding the cost of new tugs, it does not matter much, if at all, which type of drive is ordered as much as the largest variable is still the number of HP. The Z drive application has become so common that there are off-the–shelf units being marketed for new applications and for retrofits. This availability of pre-designed modules with standardized installation practices further lowers the cost and availability of Z drives. Also, the tractor designs are more for harbor use so don't have the overall waterline length and deck equipment (multiple high load winches, cranes, pumps, generators, etc.) found on large line-haul tugs, which is a major cost consideration.

Increasing and decreasing the cost, to accommodate a plus or minus $1,000,000 variation in the cost range of the tractor drive units over conventional units, creates a plus or minus range of **$58,000** in cost annually. This is equivalent to about .3% of the most likely benefit estimate.

**Calibration of Simulation Model.** The model was verified by checking to see if it could replicate the *Weather Delays to Vessels in Port* that were known to actually occur and which could be verified by reliable historical data without unreasonably distorting other parameters such as total weather days or tonnage throughput. For this verification test, the shipping years of 1997 and 1998 were selected. These years had very similar throughput, and the mine and shipping system underwent no major modifications or changes during this time period. These years had weather delay days to vessels in port of 13 and 17 days respectively and historical production of 1,086,572 tons and 1,070,735 tons respectively.

In the model, a tonnage target was set at the amount known to have been actually shipped in each year. For verification, the model was also provided with the actual ship mix that occurred in 1997 and 1998 then allowed to cycle hourly through 16 years of weather data while the wave threshold, which dictated the barge and ship loading interruption, was varied in increments of .1 meter. Setting the hourly decision criteria at a wave of .4 meter, .7 meter, and 1 meter produced the following results:

**Table 116. Variations In Weather Delay Days From A Variation In Wave Input Used To Limit Vessel Loading In The Simulator**

| | 1997 | 1998 |
|---|---|---|
| Actual Reported Weather Delay Days | 13 | 17 |
| Days With Wave set at .4 Meter in Simulation | 13 | 18 |
| Days With Wave set at .7 Meter in Simulation | 3.8 | 7.3 |
| Days With Wave set at 1.0 Meter in Simulation | 2 | 7.5 |

Variations in the limiting wave showed no direct measurable affect on the simulators calculation of throughput tonnage or vessel mix, the identifiable impact on the benefit calculation being to the vessel queue as measured by the models prediction of weather delay days to vessels in port. The model arrives at changes to weather delay days to vessels in port for the without-project condition and each of the with-project conditions. The approximate affect on the queue benefits is estimated as a 65% reduction for the .7 meter limit and 70% reduction for the 1.0 meter limit. For the 53 ft DMT project, total queue benefits are $3,333,200, and reducing them to 35% and 30% of this value, yields **$1,166,600** and **$1,000,000** respectively. The high value result, developed by inputting a wave of .4 meter, is also the most likely, because it is the only one which could reasonable duplicate actual data of 1997 and 1998.

**Deep Draft Vessel Cost.** Corps guidance stipulates deep draft vessel costs are to be supplied to field offices by the Corps planning research arm, the Institute for Water Resources (IWR). IWR issues vessel cost information for field use at approximately two year intervals. The most recent issue available was used in this study (EGM 05-1, Deep Draft Vessel Operating Cost FY 2005).

The methodology, to determine these deep draft vessel costs, is in a process of refinement. The last package of costs was issued part way through the refinement; however, the costs demonstrated a downward trend over prior issues. Aside from adoption of standard life cycle cost procedures, one of several reasons is the use of a 7-year moving average instead of 10-years for vessel replacement cost. Downward trends in replacement cost are attributed to technology and world-wide cost competitiveness.

It has been observed that shipbuilding nations have in recent years instituted aggressive subsidy programs. IWR capital cost is tied to the contract cost of new ship building over a 7-year span with updates for price level effects. The proposition has been made that, adjusting contract cost to include the subsidy effect, would be appropriate and necessary to replicate the resource cost of vessel replacement. The implication is that this could have a material affect on deep draft vessel costs. The motivation for this proposition is that NED opportunity costs are to be based on full resource values. In other words, the value of a ship should reflect all of the resources needed to build and operate it. Otherwise, being deficient in value, the ship will be improperly used; some of the resources used in its construction and operation misallocated away from higher and better uses which would otherwise pay for themselves.

There is world-wide concern that subsidies in the ship building countries are distorting the market. Recently, in accordance with the European Council Regulation establishing a "Temporary Defensive Mechanism" for shipbuilding, the European Commission authorized an offset to the effects of unfair competition from Korea in the shipbuilding sector. The scheme allows subsidies of up to 6% of a ship's contract price. These funds may be granted to shipyards in cases where has been unfair competition from Korean yards offering a lower price.[152] The Council of European Industry Ministers approved extension of European Union ship subsidies and financial aid packages also to yards in Spain and Greece. Sweden has reintroduced a 9% subsidy, and Australia has extended its 5% subsidy.

In addition to direct construction subsidies, most shipbuilding nations have other programs to help industries keep competitive. They include restructuring assistance; financing programs; scrap and build assistance; export assistance; tax benefits; customs duties, levies, and restrictions; government ownership; and R&D. European nations also use innovative tax credits. In Germany, for example, individuals or corporations who invest in ship shares receive tax reductions equivalent to 100% of their investment. Overall it is clear the previously indicated direct construction subsidies are a small part of the typical subsidy package.

The European Commission states that Korean yards have an average gap between contract price and "normal price," which is a calculated cost of production, at 18% from 8%, estimated in April 2002. With regard to India, The Times Shipping Journal reports, "...the government has announced...30% subsidy for export orders, irrespective of the type and size of the vessel."[153] This report follows an official government press release, "...With regard to shipbuilding subsidy on export order, a subsidy of 30% would be admissible on each export order irrespective of the type and size of the vessel subject to the conditions that subsidy will be calculated on the price at which the Indian Shipyard has won the global tender and where the price of the vessel is negotiated,..."[154]

[152] Marinelog Magazine, march 2003, accessed at http://www.marinelog.com/index.html.

[153] Times Shipping Journal, January 2005, Times of India of India Building, Dr. D. N. Road, Mumbai-400 001, accessed at http://www.etshipping.com/Jan2005/cstory05.html; Ph: 5635 3691/5635 3615/2273 1217.

[154] Government of India, Press Information Bureau, Press Release, March 2003 accessed at http://pib.nic.in/archieve/lreleng/lyr2003/rmar2003/13032003/r1303200315.html.

In the United States a legislated subsidy program is administered by the office of the Secretary of Transportation. The program authorization extends to 50% of the vessel cost, to wit "... for a construction-differential subsidy to aid in reconstructing or reconditioning any vessel that is to be used in the foreign commerce of the United States...The construction differential approved and paid by the Secretary shall not exceed 50 per centum of the cost of constructing, reconstructing, or reconditioning the vessel (excluding the cost of national defense features)." [155]

It is clear that subsidies exist and therefore that contract costs do not include the total cost of resources. The subsidy programs have been exacerbated in recent years, and the shortening of the moving average to 7-years would emphasize the distortion when replacement cost is estimated base on contract cost. The extent to which the IWR costs would be affected by adjusting subsidies into the vessel costs is a matter of conjecture. Although it is known the IWR data has not been adjusted for subsidy effects, the primary vessel cost data behind the IWR calculations is not publicly available. However, since vessel costs, estimated from building contracts, would not account for the full resource value, some adjustment is indicated for purposes of sensitivity. It has been assumed that the vessel costs, based on contract data, are understated by 25% for purposes of sensitivity analysis.

Vessel capital cost makes up about 48% of daily at sea cost and approximately 60% of daily in port cost.[156] The amount will vary depending on the vessel type and source of overall cost data. In this report, an unrecognized ship building subsidy, averaging 25%, is estimated to affect vessel operating cost at sea, and in port, by 12% and 15% respectively.

In this sensitivity test, an adjustment to add 25% to the vessel capital costs is used as a high range value. The IWR costs used in the report are applied as the low range value and also the "most likely" value. For each alternative the effect is to increase port and queue benefits by 15% and to increase transit costs by 12%. For the 53 ft channel, the high range port and queue benefits are $3,833,200. There is no adjustment to the transit benefit, because the number of vessels in transit is the same as the without-project condition. For the 50 ft channel, the high range port and queue benefit is $3,823,100; the high range transit benefit is ($1,109,900).

**Duration of Vessel Transit.** The most likely case uses 27 days for Panamax transits and 14 for Handysize. These are derived from an average of all vessel trips over a four year period from Portsite to the first port of call. Many vessels make more than one call, and when the additional ports of call are considered, the average trip time becomes 32 days for Panamax and 47 for Handysize.

As a most likely case, only travel days to the first port of call were counted for each of the alternative plans. Nevertheless, when channel depths of less than 53 ft are considered, more vessels are needed and hence more total travel days. Due to uncertainties that added vessels would have on the port rotation, the 2nd, 3rd, and 4th call rotation was assumed to be unchanged from the without-project condition. It is plain that the number of transit days can be adjusted up

[155] Title V, Construction-Differential Subsidy, Sec. 501. Subsidy Authorized For Vessels To Be Operated In Foreign Trade (46 App. U.S.C. 1151 (2002)), accessed at
http://www.marad.dot.gov/publications/complaw03/Title%20V%20_Contruction%20and%20Differential%20Subsidy.html.

[156] Calculated from Corps IWR EGM 99-05 as the latest publicly available deep draft vessel cost detail. Selected data for foreign flag bulk carrier, 60,000 dwt.

or down and not affect the benefits for the 53 ft NED plan. This is because an adjustment in transit days would affect the 53 ft plan the same as the without-project condition.

Using a different number of transit days, however, can have a small affect on benefits for other depths, because the number of vessels needed with the shallower channel is larger. Increasing the Panamax transit days to 32 and Handysize days to 47 results in a transit cost of **($967),** down a bit from the most likely **($991)**. This is a change of only $24,000 annually, not enough to impact plan choice or justification in a noteworthy manner. The sensitivity test, however, quiets the issue of whether the benefit evaluation needs to investigate transit times beyond the first port of call.

**Sensitivity of Results to High and Low Variables.** When the benefit analysis includes the lowest estimates with the proposition that events could conceivably combine to make the low estimates the prevailing values during the economic life of the NED plan, the benefits are decreased by only 7%. This is partly because the low range sensitivity analysis includes a compensating benefit for reduction of risk in the concentrate loading operation which is not present in the report's most likely case. When the highest estimates are used, the benefits of the 53 ft plan are increased by 50%.

The high and low range scenario results are not adjusted for probabilities. One must read into the results some judgment about the likelihood of such events occurring. It is very unlikely that events would combine to produce either the high side or the low side year after year.

**Table 117. Line Item Benefits With Highest And Lowest Results Alternative 11 With 53 ft Channel**

| | Most Likely($) | Highest ($) | Lowest ($) |
|---|---|---|---|
| Tug And Barge [157] | 10,788,300 | 10,996,500 | 10,371,900 |
| Port And Queue[158] | 3,333,200 | 4,735,700 | 1,000,000 |
| Transit[159] | 0 | (583,100) | 583,100 |
| Induced[160] | 1,707,900 | 7,299,200 | 0 |
| Fuel Variation in fuel use rates.[161] | 11,002,400 | 13,925,000 | 9,375,100 |
| Avoided Cost | 66,900 | 66,900 | 66,900 |
| Risk[162] | 0 | 4,030,400 | 3,022,800 |
| Total | 26,898,700 | 40,470,600 | 24,419,800 |

[157] Fuel cost variations.

[158] Variation in concentrate projection and simulation model wave threshold.

[159] Variation in concentrate projection.

[160] Variation in concentrate projection.

[161] Variation in fuel use rates.

[162] Variation in shipping risk.

**Table 118. Line Item Benefits With Highest And Lowest Results Alternative 11 With 50 ft Channel**

| | Most Likely($) | Highest ($) | Lowest ($) |
|---|---|---|---|
| Tug And Barge[163] | 10,788,300 | 10,996,500 | 10,371,900 |
| Port And Queue[164] | 3,324,400 | 4,774,400 | 997,000 |
| Transit[165] | (991,000) | (1,399,000) | 1,399,000 |
| Induced[166] | 1,707,900 | 7,299,200 | 0 |
| Fuel[167] | 11,002,400 | 13,925,000 | 9,375,100 |
| Avoided Cost | 66,900 | 66,900 | 66,900 |
| Risk[168] | 0 | 4,030,400 | 3,022,800 |
| Total | 25,898,900 | 39,693,400 | 25,232,700 |

**Table 119. Sensitivity Impacts Of Extremes On Optimization Of Channel Depth, Alternative 11**

| | Net Benefit Comparison | | |
|---|---|---|---|
| | Most Likely | Highest | Lowest |
| **53 ft Depth** | | | |
| Benefit | $26,898,700 | $40,470,600 | $24,419,800 |
| Cost | $22,339,308 | $22,339,308 | $22,339,308 |
| Net Benefit | $4,559,392 | $18,131,292 | $2,080,492 |
| B:C | 1.20 : 1 | 1.81 : 1 | 1.09 : 1 |
| **50 ft Depth** | | | |
| Benefit | $25,898,900 | $39,693,400 | $25,232,700 |
| Cost | $21,436,524 | $21,436,524 | $21,436,524 |
| Net Benefit | $4,462,376 | $18,256,876 | $3,796,176 |
| B:C | 1.21 : 1 | 1.85 : 1 | 1.18 : 1 |

An additional caveat is that a variation in concentrate tonnage above 1,544,000 swt annually is highly unlikely for economic, geological, and institutional reasons. However, when a variation in tonnage is tested, it can be seen that benefits in several categories are very sensitive to it. This is because added tonnage makes complex demands on the entire system from ore excavation to the milling and shipping of the final product. Added tonnage is, therefore, tied into all of the benefit categories in one way or another. It is unfortunate that this highly unlikely variable has such a major influence on benefits, because it is not discounted to recognize the low probability of its occurrence. Its unadjusted effects are incorporated in the summary results of line item benefits shown in tables 120 and 121 and in the misdirected conclusions of table 122.

Countering the table 122 distortion of this complex high consequence/low probability variable is the effect of variables with a more direct cause-effect relation, on total project benefits as shown in tables 123, 124, and 125. In these tables, the above described effect of a change in tonnage is intentionally omitted. This is to avoid the complex effects of such a highly unlikely event distorting the presentation of high and low range results from more direct linkages.

[163] Fuel cost variations.

[164] Variation in concentrate projection and shipping simulation wave threshold.

[165] Variation in concentrate projection.

[166] Variation in concentrate projection.

[167] Variation in fuel use rates.

[168] Variation in shipping risk.

**NED Plan Implications.** Combining the highest and lowest results for each benefit category leaves out the important effect of individual variables that produced differences that are not maximum differences. For example, the testing of possible changes in deep draft vessel cost are not included. This could be an important notation, because a change in the vessel cost itself is small, but it enhances the NED plan designation of 53 ft depth by an additional $118,900 annually over the "most likely" assumptions. This happens because an upward shift in vessel cost relates directly to changes in port/queue benefits and transit benefits. The 50 ft plan has a higher negative affect on transit than does the 53 ft plan so raising the vessel cost raises the negative effect of the 50 ft plan more than the 53 ft plan and reduces its net benefits.

The above presentation of combined high range and low range data is an overstatement of each case. This is because they represent the most extreme results. The likelihood of their occurrence together year-after-year is remote. This rarity of events is one reason why the high and low range are at such extremes.

Aside from above selected high range and low range combinations, there were some individual direct-linkage case situations tested. The result of including the high and low of these variables analyzed, one-at-a-time while holding all other things constant, is summarized in the following tables. The effect of previously evaluated increased tonnage is omitted from the table, because it is regarded as highly unlikely.

**Table 120. Sensitivity Summary Total Benefits With Single Variable Results Alternative 11 At 53 ft**

| Variable | High Range ($) | Low Range ($) | Most Likely ($) |
|---|---|---|---|
| Maintenance Dredging Cycle | 26,898,700 | 26,898,700 | 26,898,700 |
| Dedicated Fleet Tug and Barge Cost | 27,106,900 | 26,482,300 | 26,898,700 |
| Induced Tonnage | 28,606,600 | 26,898,700 | 26,898,700 |
| Reduction of Risk in the Concentrate Loading Operation | 30,929,100 | 29,921,500 | 26,898,700 |
| First Cost of the Trestle | N/A | N/A | 26,898,700 |
| Fuel Savings Per Gallon | 29,244,100 | 26,898,700 | 26,898,700 |
| Number of Gallons of Fuel Used by the Mine and Villages | 29,821,300 | 25,271,400 | 26,898,700 |
| Transportation Cost Savings of Moving Fuel from Portsite to Villages | 26,898,700 | 26,898,700 | 26,898,700 |
| Arrival Schedule | 26,898,700 | 26,898,700 | 26,898,700 |
| Tractor Tug vs. Conventional tugs | 26,956,700 | 26,840,700 | 26,898,700 |
| Calibration of Simulation Model | 26,898,700 | 24,565,500 | 26,898,700 |
| Deep Draft Vessel Cost | 27,398,700 | 26,898,700 | 26,898,700 |
| Duration of Vessel Transits | 26,898,700 | 26,874,700 | 26,898,700 |
| Extreme | 30,929,100 | 24,565,500 | |

**Table 121. Sensitivity Summary Total Benefits With Single Variable Results Alternative 11 At 50 ft**

| Variable | High Range ($) | Low Range ($) | Most Likely ($) |
|---|---|---|---|
| Maintenance Dredging Cycle | 25,898,900 | 25,898,900 | 25,898,900 |
| Dedicated Fleet Tug and Barge Cost | 26,107,100 | 25,750,900 | 25,898,900 |
| Induced Tonnage | 27,606,800 | 25,898,900 | 25,898,900 |
| Reduction of Risk in the Concentrate Loading Operation | 29,541,100 | 28,921,700 | 25,898,900 |
| First Cost of the Trestle | N/A | N/A | 25,898,900 |
| Fuel Savings Per Gallon | 28,244,300 | 25,898,900 | 25,898,900 |
| Number of Gallons of Fuel Used by the Mine and Villages | 28,821,500 | 24,271,600 | 25,898,900 |
| Transportation Cost Savings of Moving Fuel from Portsite to Villages | 25,898,900 | 25,898,900 | 25,898,900 |
| Arrival Schedule | 25,898,900 | 25,898,900 | 25,898,900 |
| Tractor Tug vs. Conventional tugs | 25,956,900 | 25,840,900 | 25,898,900 |
| Calibration of Simulation Model | 25,898,900 | 23,571,500 | 25,898,900 |
| Deep Draft Vessel Cost | 26,278,700 | 25,898,900 | 25,898,900 |
| Duration of Vessel Transits | 25,898,900 | 25,874,900 | 25,898,900 |
| Extreme | 29,541,100 | 23,571,500 | |

**Table 122. Sensitivity Impacts Of Single Variables On Optimization Of Channel Depth, Alternative 11**

| | Net Benefit Comparison | | |
|---|---|---|---|
| | Most Likely | High Range | Low Range |
| 53 Ft Depth | | | |
| Benefit | $26,898,700 | $30,929,100 | $24,565,500 |
| Cost | $22,339,308 | $22,339,308 | $22,339,308 |
| Net Benefit | $4,559,392 | $8,589,792 | $2,226,192 |
| B:C | 1.20 : 1 | 1.38 : 1 | 1.10 : 1 |
| 50 Ft Depth | | | |
| Benefit | $25,898,900 | $29,541,100 | $23,571,500 |
| Cost | $21,436,524 | $21,436,524 | $21,436,524 |
| Net Benefit | $4,462,376 | $8,104,576 | $2,134,976 |
| B:C | 1.21 : 1 | 1.38 : 1 | 1.10 : 1 |

**Conclusions.** The sensitivity analysis indicates the following:

- The economic justification of Alternative 11 at either 53 ft or 50 ft depth survives all of the low case evaluations.
- Designation of the NED plan depth favors 53 ft.
- Possible future upward changes in the mandated deep draft vessel costs would have the effect of enhancing the benefit-to-cost ratio and would also enhance the maximum net benefits for the NED plan.

# 18.0 SOURCES

**Sources**. Primary data sources used in the preparation of Appendix E include the listed notes and publications. Some of the documentation is considered to be personal communication not in the public domain. None of the sources are listed with the intention of having them available upon inquiry or to publish them as part of the report. Other models, sources, and data were used in a very general way while some were used in earlier stages of preparing the Economic Analysis Appendix and may not be directly related to the analysis as developed for the review draft.


1. Engineering Studies in Support of the Delong Mountain Terminal Project, USACE, ERDC/CHL TR-01-X, August 2001. Used as a source to interpret tug requirements, wave climate, vessel tracking, project dimension possibilities, and vessel pilot problems.
2. Economic and Environmental Principles for Water and Related Land Resources Implementation Studies 18 CFR Parts 711,713,714 and 715; ER1105-2-100. Used as a source for NED benefit and cost evaluation guidelines.
3. National Economic Development Procedures Manual. Overview Manual for Conducting National Economic Development Analysis, IWE report 91-R-11, October 1991. Used as a source for general evaluation concepts.
4. National Economic Development Procedures Manual. National Economic Development Costs, IWR June 1993. Used as a source for clarification of financial, economic, and opportunity cost.
5. Beyond Expected Value: Decisions Under Risk and Uncertainty, USACE IWR Order 27 DACW72-99-D-0001. Used as a source for including a risk perspective.
6. AMEC Shipping Simulator. Used as a source for throughput, delay, queuing.
7. Red Dog vessel database for 1996 to 1999, John Murphy TCAK Transportation Manager. Used to identify fleet characteristics and sailing patterns.
8. Personal communications with John Murphy TCAK Transportation Manager. Used as a source for tug labor cost, burden, hours, etc.
9. Web site for the Federal Reserve Bank of St. Louis accessible at
10. http://research.stlouisfed.org/fred/data/gdp/gdpdef. Used as a source to establish the GNP price deflator.
11. Deep Draft Coastal Navigation Entrance Channel Practice, U.S. Army Corps of Engineers Technical Note 1-63, March 1999. Used as background information to explain under keel clearance, and vessel squat expectations of the bulk carriers.
12. DRAFT RESOURCE TRANSPORTATION ANALYSIS, PHASE 1-PROGRAM DEFINITION, table 2-1, prepared for Alaska Department of Transportation and Public Facilities, April 2001 by Ch2M Hill and Associates. Used as background document to assess/verify resource potential.
13. Personal communication, January 2002, Bob Jacko, General Manager, Teck Cominco Alaska. Used to verify mine output.

14. Personal communication, John Wood, AIDEA, January 2002. Used to verify a brief summary and description of AIDEA shipping agreement.

15. RED DOG MINE COMINCO'S ALASKAN TRIUMPH, Jane Werniuk, appearing in The Canadian Mining Journal April 2000 (Table total calculated for this report). Used as a reference for resources and reserves.

16. ZINC MARKET, PRICE AND TREATMENT CHARGE OUTLOOK, Prepared for AIDEA by Brook Hunt, 1998. Used as background in the discussion of Zinc price expectations in the commodity projection.

17. THE ZINC MINE-SMELTER INTERFACE: INVESTMENT, INTEGRATION AND IMPLICATIONS FOR THE CONCENTRATE BALANCE, Speech to Metal Bulletin Conference, Dublin, May 2000. Chris Parker, Zinc Mine Analyst, Brook Hunt. Used as background for interpretation of expectations and long term trends in zinc prices.

18. Web site at << http://mars3.gps.caltech.edu/whichworld/explore/trends.html>>. Used as an example of interactive futures planning, and the importance of recognizing and specifying assumptions.

19. A FIVE-YEAR OUTLOOK FOR THE GLOBAL LEAD AND ZINC INDUSTRIES, a copyrighted presentation prepared by CHR Metals Limited, and delivered at Xiaoshan, China by Claire Hassall and Huw Roberts, March 2001, with the permission of CHR Metals. Used as a source to characterize views on the world outlook for zinc.

20. 1997 Report on the World Social Situation, United Nations publication swt/ESA/252, accessible at <<http://www.un.org/esa/socdev/rwss97c0.htm>>. Used as a source for expectations of global growth, related international changes and a relation to future trends in zinc consumption.

21. Personal communications with Jozef Plachy, USGS Zinc Commodity Specialist, jplachy@usgs.gov and Carl A DiFrancesco, Minerals and Materials Analysis Section, USGS <difrance@usgs.gov>. Data and opinion to assist in interpretation of historical prices and consumption of zinc in the commodity projection.

22. AME Mineral Economics cited as a primary source in DRAFT RESOURCE TRANSPORTATION ANALYSIS, PHASE 1-PROGRAM DEFINITION, prepared for Alaska Department of Transportation and Public Facilities, April 2001 by Ch2M Hill and Associates. Used as a source for near term expectation of $.53 per lb zinc.

23. U.S. Bureau of the Census, International Data Base accessible at

24. <<http://www.census.gov/ipc/www/worldpop.html>>.

25. Data for 1980–2000 from WORLD DEVELOPMENT REPORT 2000/2001: ATTACKING POVERTY, August 2000 by Oxford University Press, World Bank ISBN: 0-19-521129-4 SKU: 61129. Used as a source for historical trends and future expectations.

26. COMINCO ANNUAL REPORT FOR THE YEAR 2000, and 1999. Data relating to Red Dog Mine operations, sales, cost, profit etc.

27. Personal communication, Greg Waller, Teck Cominco Alaska. Information relating to future production options at Red Dog Mine.

28. Teresa Imm, Arctic Slope regional Corporation, in a February 2001 telephone interview with Bill Wong noted in Northwest Alaska Resource Development Transportation Alternatives Study, prepared for Alaska Industrial Development and Export Authority by CH$^2$M Hill and Sandwell Inc. Background interview relating to coal development opportunities.

29. U.S. Army Corps of Engineers, ER 1105-2-100, 22 April 2000, page D-21. Used as guidance to include an adjustment for salvage value in life cycle cost estimates.

30. Personal communication in July 2002 with Brian Trenhaile, Naval Architect and Marine Engineer, Hawaii Marine Company, Kaneohe HI. Used as expert source to establish multi fuel capabilities of actual vessels operated.

31. Personal communication in July 2002 with EG Duarte and Associates, Naval Architect. Used as an expert source to verify common multi fuel capabilities of tanker vessels and common use of carriers in multi fuel deliveries among west coast ports.

32. Clarkson's Bulk Register in U.S. Army Corps of Engineers Columbia River Channel Deepening feasibility report and EIS, Appendix C. Used as a source of trends in size of bulk carriers.

33. Web site accessible at <<//www.eia.doe.gov/emeu/sedr/contents.html>>. Used as support for a statement that over the last 20 years, fuel use in the state has not shown an appreciable increase, and a review of the state and regional economy shows that there are no concrete economic changes of a structural nature on the near horizon which would bring about a change in patterns of use or amount of use

34. Personal communication with Dave Brennan, AVEC, Anchorage, October 2002 supporting that AVEC does no longer maintain a record of fuel delivery cost to specific locations but has cost records pertaining to area deliver contracts for groups of villages. Details of generator efficiencies at specific locations are not available. Village rate data obtained and explained. Delivery problems and cost discussed.

35. Personal communication with Tom Bohlen, NWAB. Used to identify a scenario including pre-season plans for fuel delivery during the Year 2002 season.

36. Design fuel barge in AGRA Project A151H Report, 12/29/2000, Section 6, page 2. Used to arrive at an estimated capacity of barges delivering to Portsite historically.

37. Economics Guidance Memorandum (EGM) 00-005, HQUSACE, CECW-PD. Used to derive cost per displacement ton as a basis for barge cost of larger vessels.

38. West Coast and Alaska Marine Fuel Prices 1999–2001, Economic fisheries Information Network, Pacific States Marine fisheries Commission, 7600 Sandpoint Way NE Seattle WA 98115. Used to document retail fuel price from actual sales of marine diesel at ports in western Alaska.

39. Web site access at www.eia.doe.gov. Used to determine Federal views on domestic oil price trends.

40. FY 2002 PLANNING GUIDANCE DEEP DRAFT VESSEL COSTS, Economics Guidance Memorandum (EGM) 02-06, Deep Draft Vessel Operating Costs, CECW-PD, undated

release provided to field in October 2004. Used to establish deep draft vessel characteristics and cost.

41. Website, Maritimesales.com, accessed on 20 Dec '01. Provided value data relating to tugs on the market in 2001 with an age of 30 years. Data was in turn reduced to cost per horsepower. Salvage value of the barge is arrived at by establishing a scrap value of $145/ton for hulls from the vessel scrap market and an estimated light displacement of 3,500 tons. Web site http://www.shipiq.com/viewfeaturestoryWWW.asp?ID=34, also provided data from a listing at $150 U.S. per LDT, other listing in <<http://www.metalworld.com/a/view/0119.html>> accessed Oct 2002, and listings in<<ship2break.com accessed in Feb '02.

42. Application of methodology and parameters in EP 111-1-8 to calculate hourly operating cost of tugs.

43. Economics Guidance Memorandum, (EGM) 00-05, Estimated Towboat and Barge Costs USACE CECW-PD. Used as a source to establish non-arctic operating days at 350 and 24 hours per. Used also as a source to establish capital and operating cost, and life of tugs and barges.

44. Website, Maritimesales.com, accessed Dec '01 and notes. Used to establish value of 1,500 HP unit based on equipment in use, in addition to the comparable vessel used for the value estimate.

45. Personal communication with Bob Beegle, President Marcon International, P.O. Box 1170, 9 NW Front St. Coupeville, WA 98239-1170, U.S.A. Notes and data from Marcon.com website provided value data regarding vessel sales. Data was used to establish rule of thumb guidance (ground truth) for tug cost per HP.

46. Web site, << http://wizard.ucr.edu/~bkaplan/alcf/acftdata.html>>. Used as a source to establish C-130 pertinent capacity data and operational parameters, and cost comparisons.

47. Personal notes in the form of TCAK data of tonnage shipped in 2001 and actual fuel used. Used for estimated fuel consumption. (Fuel conversion applied a specific gravity of .81, 6.8 lb/gallon, and 294 gallons per ton. This represents a balance of gas oil and kerosene).

48. Web site access to Alaska Community and Economic Development Database. Used as source for community characteristics, employment, population etc appearing in the Economic Base and Fuel Use Analysis. Data was applied also to estimate fuel use per job in a sample year from data for 9 small coastal villages at 2,900 gallons per employee. In contrast the per employee use at Nome is 5,500, and at Kotzebue is 4,780, however use rates at regional economic, transportation, health and government centers are untypical of smaller coastal villages.

49. Personal communication with Patsy Neakok, NSB 6/26/02. Used as a source for fuel delivery practices and volumes to Point Hope, Point Lay, Wainwright, and Barrow.

50. Web site access <http://www.crowley.com/cms/petroleum_transport.asp> . Used to verify size and type of ocean equipment in use.

51. Web site access <http://www.fwav.com/new_construction_details.htm Established that newly designed tugs of 4,000–6,000 HP carry 92,000 gallons of fuel.

52. Articles in state of Alaska sponsored publications such as, Alaska Economic Trends, Alaska Department of Labor and Workforce Development, Research and Analysis Section. Used as a source of selected data and discussion of economic characteristics of boroughs and census areas.

53. state of Alaska Community and Economic Development Database. Used as a source of statistics and text excerpts describing communities, population, employment, trade, earnings etc.

54. U.S. Department of Commerce, Bureau of Economic Analysis, and Bureau of the Census. Used as a source for population and economic characteristics.

55. RESOURCE TRANSPORTATION ANALYSIS, Draft PHASE 1 Report, Dec 1992. Used to verify that prior transportation studies did not identify economically viable coal resources.

56. U.S. Census Bureau, Consolidated Federal Funds Report FY 2000. Provided data relating to transfers.

57. Website access, << http://www.dced.state.ak.us/cbd/commdb/CF_BLOCK.cfm>> Data from the Community Data Base, North Slope Borough. Used to establish employment, population and earnings data.

58. Web site access to World Mine Cost Data Exchange available at website

59. Minecost.com. Used as a source for world mine cost model and also a model of Red Dog Mine. The models were used to estimate a supply curve and mine operating cost at different output levels.

60. Website access to << http://data.bls.gov/cgi-bin/surveymost>> Providing the Bureau of Labor Statistics Producer Price Index for the metals mining industry. Used as a source for price index data for the mining industry.

61. Web site access to http://www.lme.co.uk/data_prices/home.html>> Used as a source for metals prices.

62. Personal communication with Jim Burns, Vintage Marketing, 16200 Luna Street, Anchorage Alaska 99516. Used as an independent Corps contractor to establish the fuel price differential between Puget Sound, Kenai Peninsula, and Singapore.

63. Web site access to http://www.hq.usace.army.mil/cemp/C/costbus2 . Used as a source for an estimate of ordinary labor overhead. Site references FY 97 costs and shows a displays a Powerpoint presentation by Jim Lovo, Construction Programs Management, HQUSACE.

64. Web site access to http://planequest.com/operationcosts/op_cost_info.asp?id=15. Used as a source for comparison of aircraft operating cost.

65. Web site access, Human Needs Committee Meeting Draft Minutes, July 25, 2001 Teleconference Meeting, BBNA Conference Room, posted at http://www.bbna.com/fish2001/fish05.htm. Used as a source for competing fuel service out of Adak.

66. Web site access, Annual Energy Outlook 2004 with Projections to 2025, Report #: DOE/EIA-0383(2004), Release date: January 2004. Accessed at

http://www.eia.doe.gov/oiaf/aeo/. Used as a basis for the presumption of petroleum price stability over the long-term.

67. Web site access at http://www.nana.com/pdfs/NANA%20and%20Mining.pdf. Used as a source to indicate that the resource owner anticipates a 50-year mine life.

68. Web site access at Http://www.iza.com for the report titled, Zinc and Sustainable Development The Case of the Red Dog Mine, Doug Horswill, Deirdre Riley and David, Parker Cominco Ltd, in Zincworld, 68 Avenue de Tervueren Box 4, B-1150 Brussels, Belgium. Used to present industry and mining company expectations that the mine life will exceed 40-years.

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